AGRICULTURAL ENGINEERING

NOVEMBER • 1954

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The Development of Handling Equipment for Applying Anhydrous Ammonia Fertilizer

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Agricultural Engineers Develop New Data on Head Loss in Irrigation Couplers

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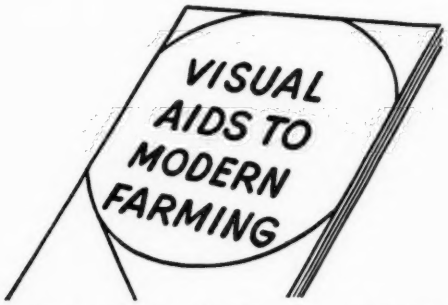

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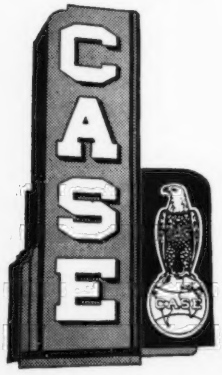

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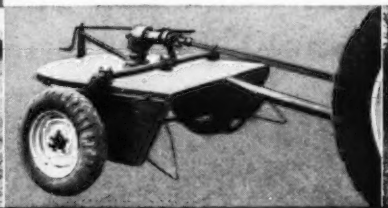

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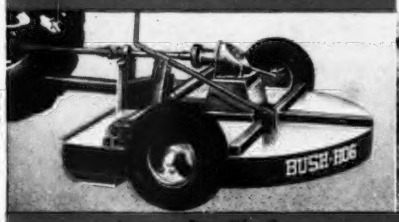

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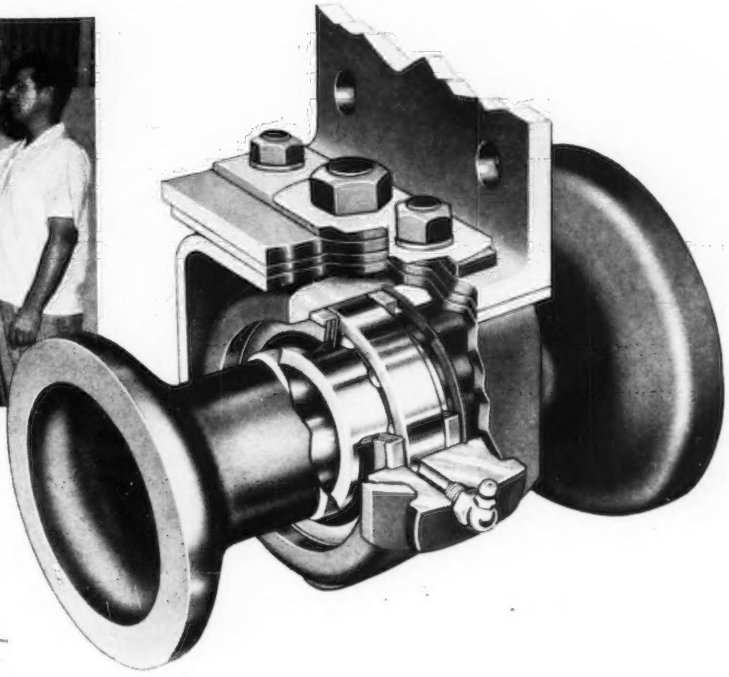

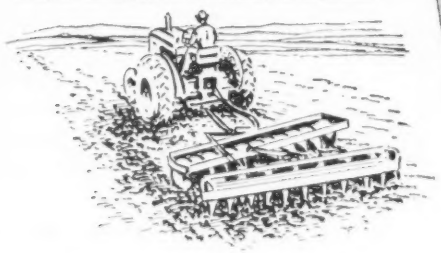

WHEN western growers get together to talk farm machinery, you can bet the entire Rockies to one small sand dune that the talk is big. And, friend, that's simply because out that way the machinery itself is big.

Take the husky John Deere-Killefer Disk Harrows, for example. These all-steel giants that are cutting old tillage records to ribbons all over the West work a swath as wide as eighteen feet, and their huge disk blades—ranging up to 24 inches in diameter—churn the soil into a mellow seedbed that is often as deep as nine inches. Weighed, the large ones would tip the scales just on the thin side of two and a half tons!

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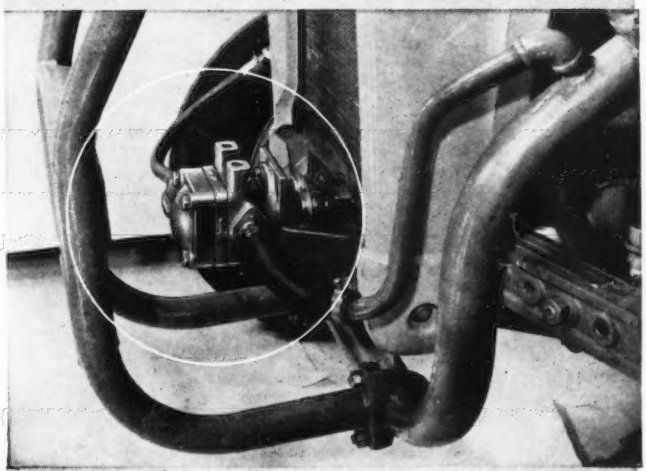

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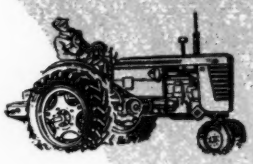
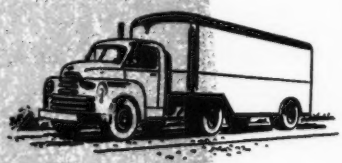
THIS PUMP OPENED NEW DIESEL MARKETS...

THE AMERICAN BOSCH "PSB"





American Bosch's development of the PSB single-plunger pump made it possible for engine manufacturers to produce the smaller, lower-cost Diesels which have opened up new markets for Diesel power. You see it serving everywhere —on efficient Diesels that power farm tractors, compressors, generating sets, boats and trucks in ever-increasing numbers.

Today, more Diesel engine manufacturers are using the American Bosch PSB as standard equipment than ever before. It's easy to see why —for the PSB gives both the engine manufacturer and the user a simplified, compact, lower-cost pump with a *proven* record of outstanding performance and dependability *plus* ease of servicing and low maintenance expense.

The PSB is a product of American Bosch's continuing program of research and development. It stands as a significant contribution to the progress of the Diesel.

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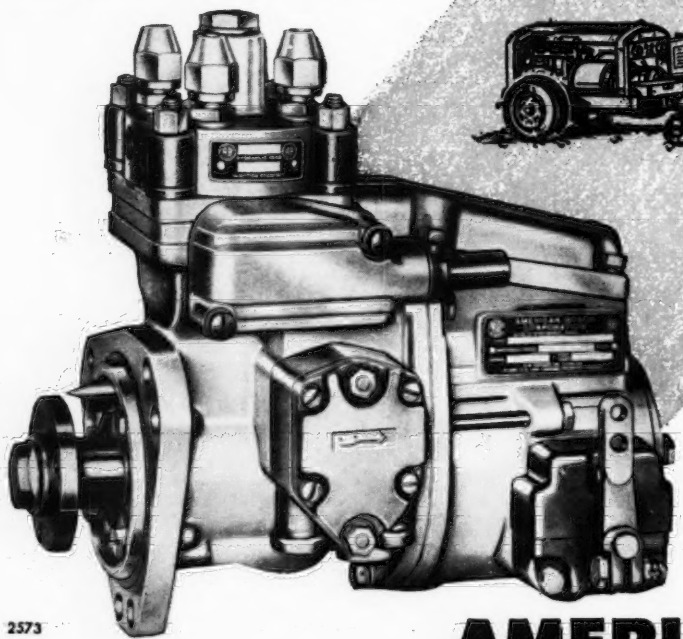

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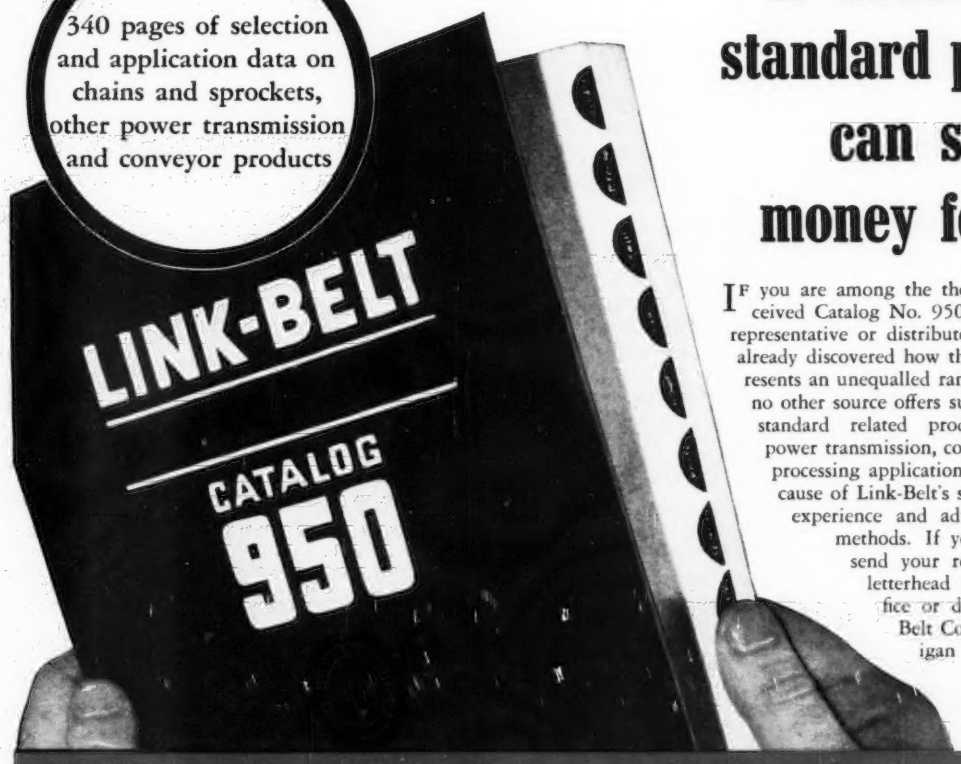

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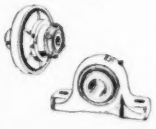
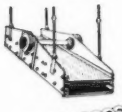
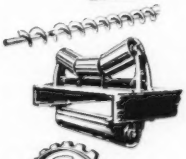


Bearings—ball, roller, babbitted and bronze. *Rigid and flexible couplings.* Take-ups, hangers, bushings, pulleys, gears, clutches, backstops, shear pin hubs, collars, grease cups.



Processing equipment—vibrating screens, icing equipment.



Conveyors—Flexmount oscillating and piano-hinged apron. *Components* for screw, belt and trolley conveyors. *Car spotters and pullers. Power unloading scoops. Bucket elevators and elevator buckets.*

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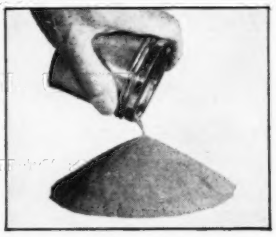
How IH uses POWDERED METAL to help farmers save costly grass seed

New band seeding methods enable farmers to get good stands of grasses and legumes, saving up to 30 per cent in seed. But drilling as few as five or six pounds of tiny seeds per acre calls for extremely accurate seed metering.

To improve accuracy without increasing cost of the feeds used in grass seed attachments for McCormick® grain drills, IH manufacturing research and production engineers turned to a study of powdered, or sintered metal—a relatively new metallurgical process for economically mass producing certain types of precision parts.

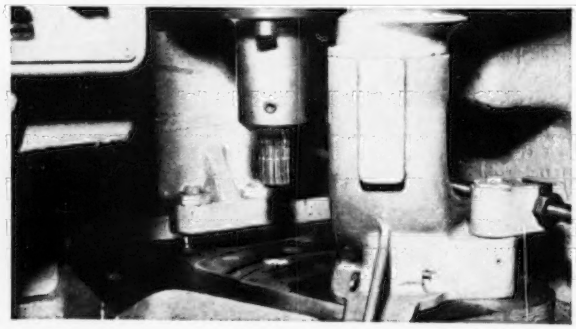
Extensive tests developed the correct "recipe" of powdered iron, copper, and other ingredients; the correct pressure for compressing the powder into form; and the correct temperature for bonding the metal particles in a sintering furnace.

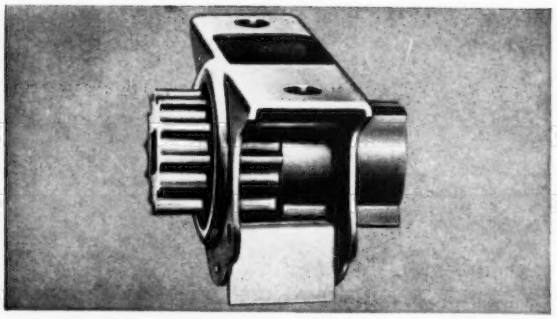
The accompanying photographs show some of the steps by which powdered metal is transformed into grass seed drill feeds of greater precision, providing more uniform seed distribution, and minimizing seed leakage.



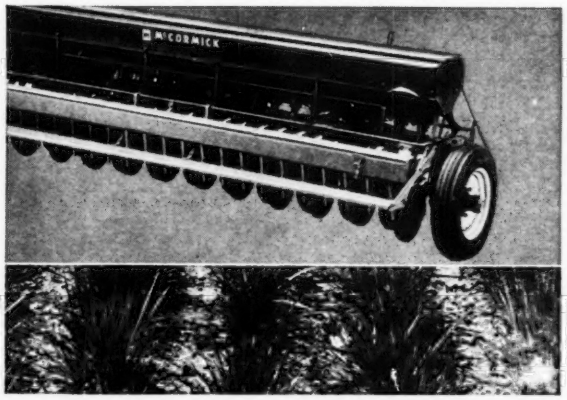
The new grass seed drill feed starts with powdered iron, blended with the correct amount of copper, plus a wax to lubricate the dies.

Next, using a hydraulic press with precision dies, the powder is compressed under 40 tons per square inch pressure, forming a "green" compact. This compact is then firmly bonded by sintering for approximately 30 minutes in a furnace at 2050 degrees F.





Here is the finished feed cup assembly with fluted metering wheel and cut-off thimble of sintered metal, with an oxide finish to resist corrosion. Forming these parts from powdered metal in precision dies results in strong feed rolls, each with concentricity uniform to within three thousandths of an inch—as compared with an average of 15 thousandths of an inch for grey iron castings.



Above, a McCormick drill equipped with the new attachment for seeding grass and legume seeds in bands, saving users up to 30 per cent in seed cost. Below, a good stand of a band-seeded grass mixture.

Many other parts of sintered metal have been adopted or are being developed through the teamwork of IH research, design, metallurgical, manufacturing, and field test engineers, working toward the common goal of improving the quality and performance of IH equipment while keeping costs at a minimum. The result is product leadership that helps farmers everywhere reduce production costs and thereby increase farm profits.

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City.....*Zone*.....*State*.....

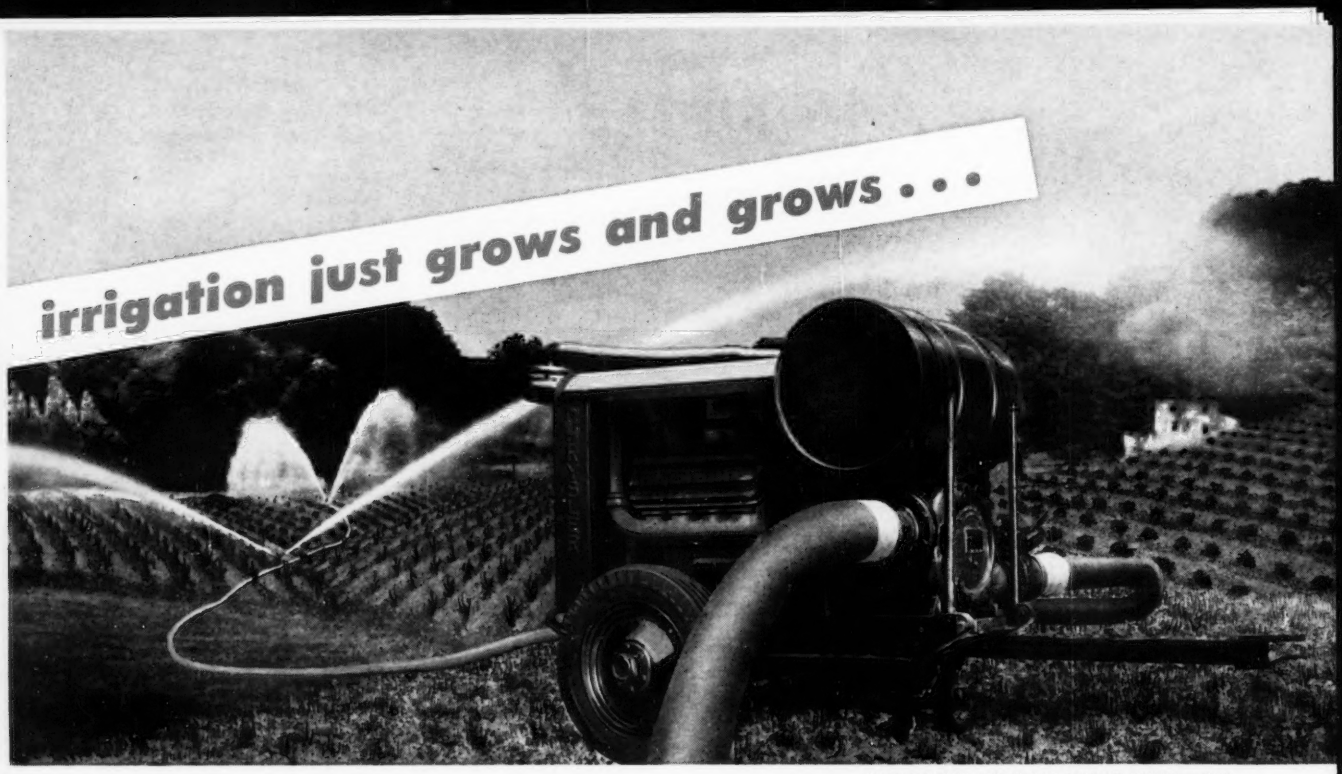


PHOTO COURTESY GORMAN-RUPP COMPANY, MANSFIELD, OHIO

gallons of water for thirsty acres with modern, thrifty **CHRYSLER V8** *hemispherical combustion*

With irrigation, every farmer and grower can virtually assure himself a record crop *every* year. The investment in pump, pipe and sprinklers pays for itself in a surprisingly short time.

Here is a Gorman-Rupp single-stage centrifugal pump designed especially for portable pipe irrigation systems. It is drawing 850 gallons of water per minute from the river to irrigate several acres of corn. To maintain this gallonage at 130 pounds pressure, its 331 cubic inch displacement Chrysler Industrial Model 24 V8 Engine is turning at only 76 per cent of its maximum governed speed.

Like other leading manufacturers, Gorman-Rupp picks the Chrysler Power that will match its equipment requirements. For example, smaller pumps are powered with Chrysler Model 30 and 16 Engines which deliver ample power for those units; but, since this Model 55M Pump was designed for high capacity pumping, Gorman-Rupp installs the 180-horsepower Chrysler Industrial Model 24 V8 Engine. Result of using this modern short-stroke, low friction engine: High water volume *plus* outstanding operating economy.

Regardless of the type of equipment you manufacture, if it requires industrial power within our 230 to 413 cubic inch displacement range, there's an economical power-proved Chrysler Industrial Engine to meet your requirements, and a long list of optional equipment items with which your engines can be factory-equipped for *better* specialized performance.

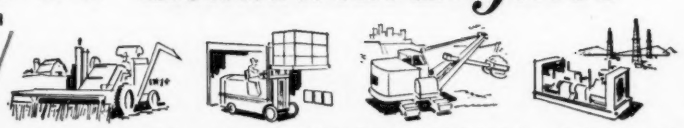
And remember, Chrysler Power is not expensive. Production-line methods adapted to specialized industrial engine building provide a custom-built engine at mass-production prices.

Before you install any engine, see a Chrysler Industrial Engine Dealer or write for detailed information: ***Dept. 1611, Industrial Engine Division, Chrysler Corporation, Trenton, Mich.***

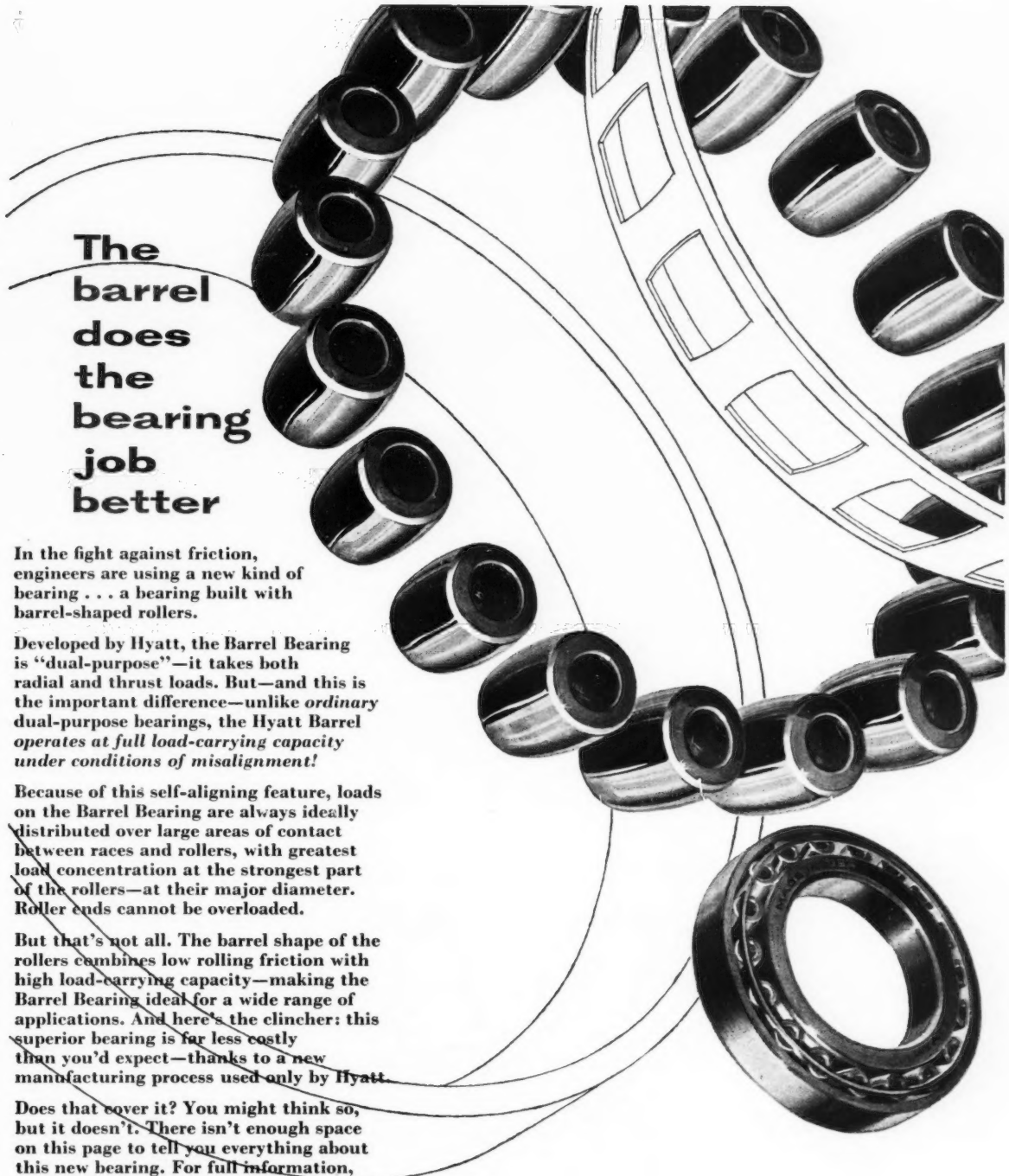
CHRYSLER *Industrial Engines*

INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

HORSEPOWER WITH A PEDIGREE



AGRICULTURE • INDUSTRY • CONSTRUCTION • OIL FIELDS



The barrel does the bearing job better

In the fight against friction, engineers are using a new kind of bearing . . . a bearing built with barrel-shaped rollers.

Developed by Hyatt, the Barrel Bearing is "dual-purpose"—it takes both radial and thrust loads. But—and this is the important difference—unlike *ordinary* dual-purpose bearings, the Hyatt Barrel *operates at full load-carrying capacity under conditions of misalignment!*

Because of this self-aligning feature, loads on the Barrel Bearing are always ideally distributed over large areas of contact between races and rollers, with greatest load concentration at the strongest part of the rollers—at their major diameter. Roller ends cannot be overloaded.

But that's not all. The barrel shape of the rollers combines low rolling friction with high load-carrying capacity—making the Barrel Bearing ideal for a wide range of applications. And here's the clincher: this superior bearing is far less costly than you'd expect—thanks to a new manufacturing process used only by Hyatt.

Does that cover it? You might think so, but it doesn't. There isn't enough space on this page to tell you everything about this new bearing. For full information, write to the address below.

HYATT ROLLER BEARINGS

STRAIGHT BARREL TAPER

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, N. J.

Tomorrow's tractor fuel is here . . . *today!*

People are curious about the future of farm power. They want to know what's ahead for tractors, tractor engines and fuel. Some of the questions can't be answered, but a recent research project holds every promise of answering the question of fuel.

The Oliver Corporation built an experimental tractor engine to see how an advanced-design engine would take advantage of gasoline's power potential. They used a high-compression ratio of 12 to 1 to squeeze the most work out of high-octane fuel. Test results showed the engine produced *44% more* power than one of today's high-performance tractor engines. It also set a new high in economy, operating on *30% less* fuel than today's engine!

These results definitely say what tomorrow's tractor fuel will be. It's gasoline . . . and it's here today.

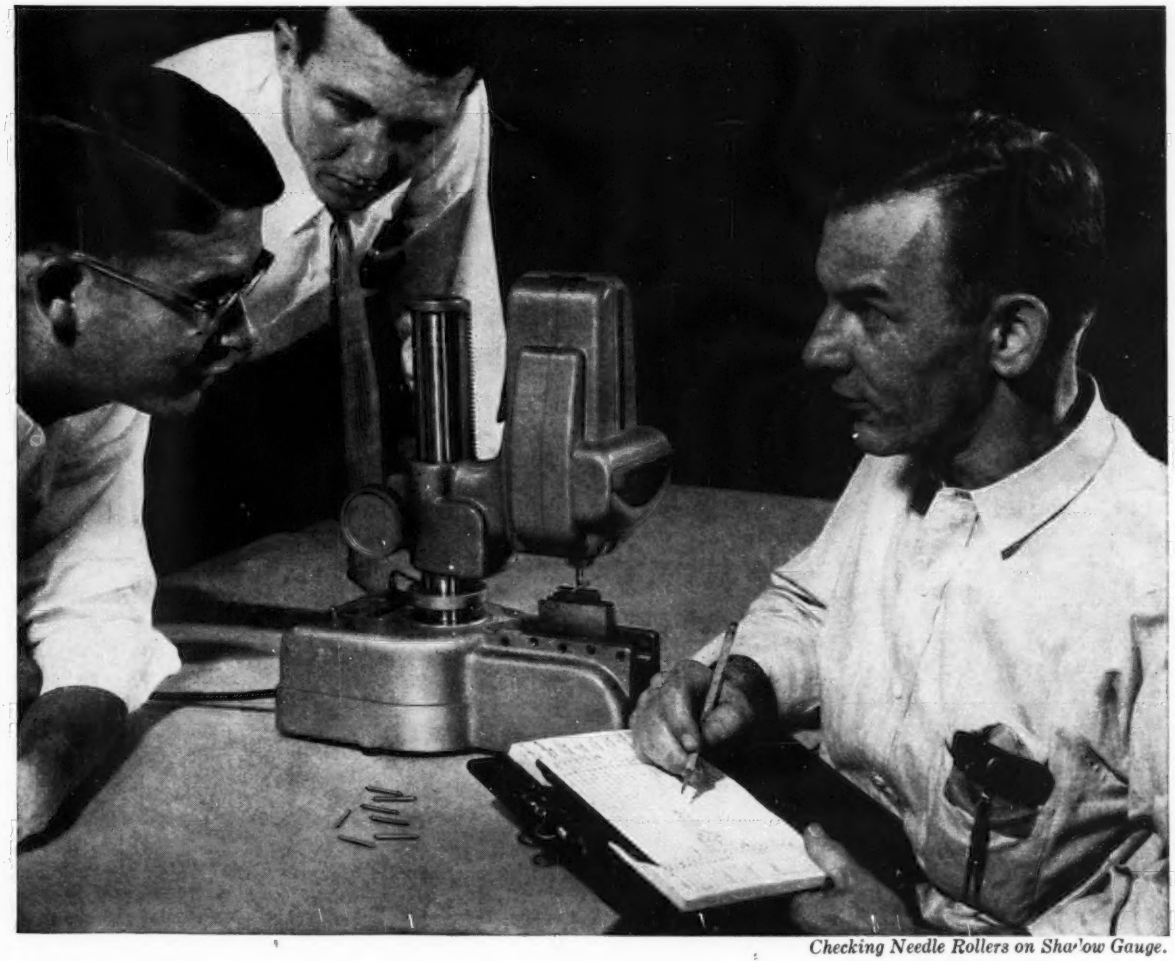
Over the last 25 years, there have been startling improvements in gasoline. The three primary quality characteristics—volatility, freedom from impurities, high antiknock value—are at a level never before attained.

Modern refining plus "Ethyl" antiknock compound has raised octane numbers to an all-time high. The petroleum industry now "custom-builds" a fuel of exact volatility for precise performance according to the season and climate of a particular area. Rapid advance in refining methods and development of specialized new additives have reduced impurities to inconsequential levels. And the industry predicts even higher quality to come.

These great advances easily explain why gasoline has been labeled the "fuel of the future." And why farmers can expect to enjoy a new era in tractor power in the years to come.

ETHYL CORPORATION

New York 17, N. Y.



Checking Needle Rollers on Sha'ow Gauge.

"This triple check means long service life for TORRINGTON NEEDLE BEARINGS"

The workmen who grind rollers for Torrington Needle Bearings constantly check their work against master rollers on a shadow gauge—an instrument sensitive to variations of .000025".

Throughout the day, an inspector checks each operator's work and master roller against *another* master, and plots the production information on a Statistical Quality Control Sheet. As a triple precaution, both the operator's and the inspector's masters are checked daily against "Jo" blocks.

These constant measurements, and the control records they provide, are only a few of the many critical inspections—from metallurgical analysis of raw materials to running tests of each finished bearing—that assure the long life and high capacity of Torrington Needle Bearings.

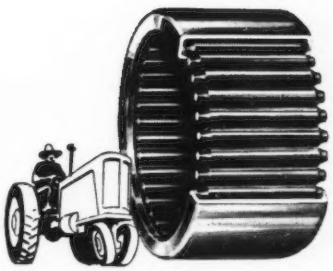
The Torrington Company has helped with thousands of different Needle Bearing applications throughout industry over a period of twenty years. Our Engineering Department offers the benefits of its experience in applying Torrington Needle Bearings to your products.

THE TORRINGTON COMPANY
Torrington, Conn. South Bend 21, Ind.

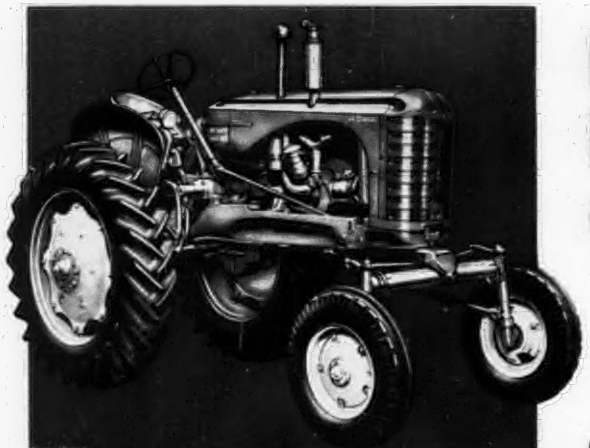
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers



Tractors, harvesters, combines, mowers and many other farm machines produced by leading manufacturers utilize Torrington Needle Bearings to good advantage. In main drives, crankshafts, gearboxes, idler pulleys, steering gears, hydraulic pumps and a host of other assemblies, Needle Bearings take the punishing loads of daily farm use.



Massey-Harris 44-D Cane Special Tractor with Drop Axle using Diamond Roller Chain.

Massey-Harris Clipper Combine

Massey-Harris Self-Propelled Corn Picker

DIAMOND ROLLER CHAINS

DIAMOND ROLLER CHAINS

Trade Mark

ON EQUIPMENT WHERE ONLY THE BEST IS GOOD ENOUGH

Wherever farm machinery is used, Massey-Harris-Ferguson has high rating. Quality with a purpose has paid off their many users in top long-life efficiency and economy throughout a half century.

Quality with a purpose has been a basic characteristic at Diamond, too, since 1890—so that Diamond Roller Chains have become universally recognized for their uniformity of quality, long-life dependability and efficient performance.

Diamond Roller Chains are made in a wide range of pitch sizes to meet power transfer requirements from a fraction of a horsepower to several thousands. The quality trade-mark—the Diamond—is stamped on every link.

New Catalog 754 contains useful Roller Chain and Sprocket engineering and application data. A copy will be mailed on request.

DIAMOND CHAIN COMPANY, Inc.

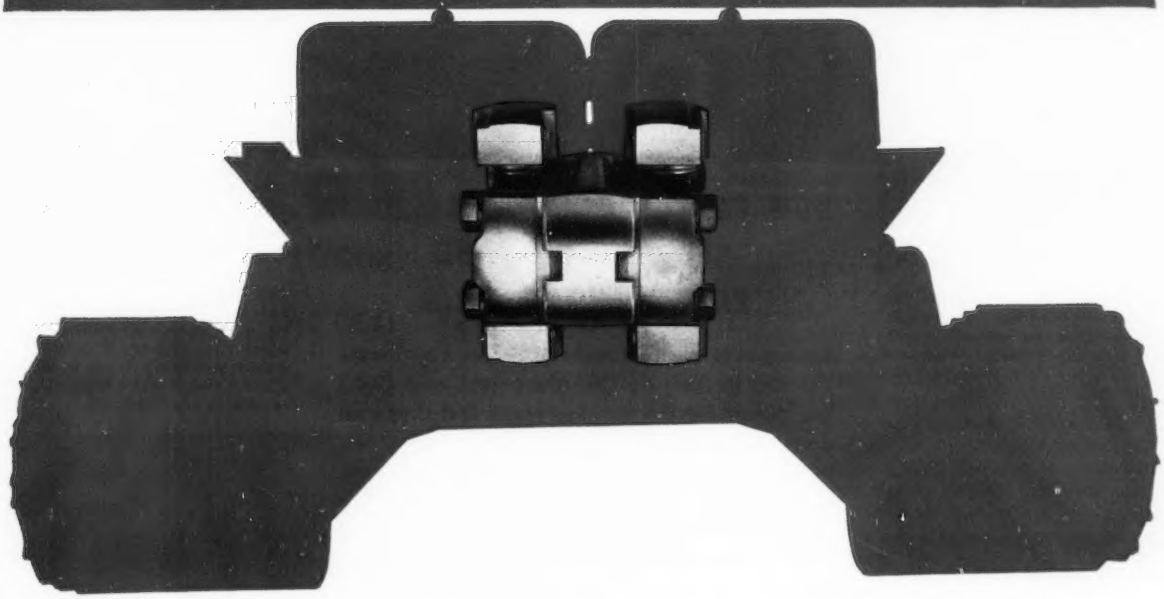
Where High Quality is Traditional

Dept. 616, 402 Kentucky Avenue, Indianapolis 7, Indiana

Offices and Distributors in All Principal Cities

Please refer to the classified section of your local telephone directory under the heading CHAINS or CHAINS-ROLLER

COMPACT



MECHANICS close-coupled type Roller Bearing UNIVERSAL JOINTS are specially designed for operation within cramped quarters, and where shafts are out of alignment — as in twin-tractor power unit silhoutted above and in rear engine cars, tractors, trucks and busses. Let our engineers show you how these MECHANICS joints will conserve space and compensate for offset shafts, in your new models. These joints fit into spaces that engineers formerly considered too short for universal joints. Our new catalog — showing complete line of MECHANICS Roller Bearing UNIVERSAL JOINTS and containing handy joint tracing kits — will be sent to manufacturers, upon request.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2046 Harrison Ave., Rockford, Ill.

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

With a FLECO Rock Rake, this D6 clears timber and brush. Outfit concentrates the tractor push on stumps or brush and sifts soil from roots without moving excessive dirt.

This Cat D6 Tractor pulls a heavy-duty Rome plow through dense palmetto. This outfit can work through most scrub growth and heavy brush up to 2" thick, reducing it to chopped residue in one operation.

HOW FARM POWER CONTRACTORS ARE CLEARING LAND FASTER AND EASIER...

Farm power contractors have chosen Cat® Diesel Tractors as their No. 1 earthmoving, land clearing power for the simple reason that they can depend on them to stay on the job and cost less to operate. As a result, Caterpillar track-type Tractors have moved more dirt . . . cleared more land than any other man-made power on earth! Now, a variety of specialized tools make land clearing even more efficient than ever. Illustrated here are a few . . . for complete information, write us.

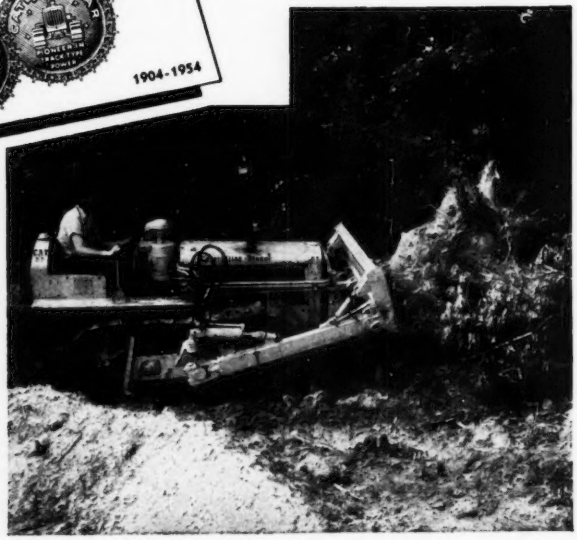
Caterpillar Tractor Co., Peoria, Ill., U.S.A.

Diesel Farm Tractors • Tool Bars • Implements

CATERPILLAR®

Though the Cat D4 Tractor develops about the same horsepower as large wheel-type tractors it has about twice the push or pull power. Its 10,600 pounds of push or pull make it an ideal farm-owned tractor for land clearing. Shown equipped with FLECO® Tree Cutter.

The Cat-built Bulldozer is the favored method of land clearing, because of its universal use. Works equally well for earthmoving. Low cost tool bar 'dozer shown on the Cat D2 Tractor.



Greenwood Dairies' milk quality shows vast improvement with the bulk handling system

PAUL SAUERBRY, owner of Greenwood Dairies, measures the amount of milk in the Stainless Steel tank on the farm of one of his producers.

	JAN. 13, 1953	JAN. 15, 1954
Farm A	46,000	20,000
Farm B	62,000	16,000
Farm C	14,000	2,000

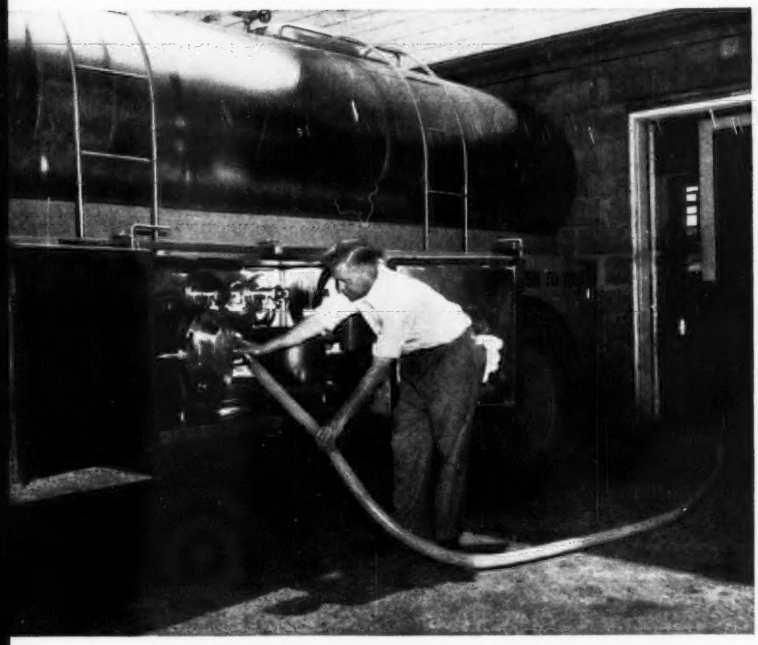
These figures are bacteria counts in the milk samples taken from three of the producers supplying Greenwood Dairies, Langhorne, Pa. The principal reason for the significant drop in each case was a switch to the bulk milk handling system in Stainless Steel tanks.

Paul Sauerbry, owner of Greenwood Dairies, finds milk quality at the farm level vastly improved since his 20 producers installed Stainless Steel farm tanks. He used to accept milk with a count up to 100,000. He has cut the figure to 50,000 now and rarely rejects milk. Since Greenwood Dairies installed the bulk handling system, it has consistently been among the top 10 dairies of 39 in the area in low bacteria count.

The bulk handling system results in higher butterfat content, too, because it reduces stickage losses. As a result, farmers are averaging five to ten cents more per hundredweight for their milk.

Faster pickups from the bulk tanks has made possible reduced hauling charges. The record run was 22,585 pounds of milk picked up in 5½ hours. Hauling charges at the Greenwood Dairies have been reduced 15 cents per hundredweight for producers who own tanks.

Investigate the bulk handling system that makes possible such an improvement in milk quality accompanied by a reduction in labor and costs. As the producer of USS Stainless Steel, from which many farm tanks are made, we have worked closely with manufacturers of these tanks. We'll be glad to put you in touch with our customers for detailed information. Mail the coupon.



MR. SAUERBRY starts the pump that transfers milk from the Stainless Steel farm tank to the Stainless Steel pick-up truck.

Agricultural Extension Section
United States Steel Corporation, Room 4780
525 William Penn Place, Pittsburgh 30, Pa.

Please send me literature about farm bulk milk equipment. Send information to:

Name.....

Title.....

Company.....

Street.....

City.....Zone....State.....

United States Steel is a steel producer, not a bulk milk equipment fabricator. Your request, therefore, will be sent to manufacturers who fabricate bulk milk equipment for farm use.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS • STRIP • PLATES • PIPE • TUBES • WIRE
BARS • BILLETS • SPECIAL SECTIONS

UNITED STATES STEEL

Here's the New Holland Forage Harvester with Row Crop attachment at work on a stand of corn. Cut-away above shows the construction of the BCA Flange Bearing used on the jackshaft drive.

BCA FLANGE BEARINGS

cut costs for manufacturer and farmer on the New Holland Forage Harvester

BCA Flange Bearings are low-cost, pre-lubricated *package units*. The two halves of the bearing outer ring are formed into a triangular flange with three evenly-spaced bolt holes: the flange easily is bolted to the equipment to provide a simple, economical installation. The bearing design permits some misalignment of equipment members. The extended end of the inner ring is machined to mate with an eccentric lock ring. A twist of this ring locks the bearing to the shaft without the need for machining the shaft, even when "commercial grade" shafting is used.

New Holland Machine Company makes the most of these advantages by using a BCA Flange Bearing to support the front end of the jackshaft drive which is mounted on the base unit of the New Holland Forage Harvester and used to drive the row crop and sickle bar attachments. This brings the *farmer* benefits, too. He has no field-servicing problems because the rugged BCA Flange Bearing stands up to the toughest kind of punishment, and two synthetic seals resist the entrance of grit and dust in addition to retaining within the bearing a stable, long-life, water-resisting grease.

The BCA Flange Bearing is typical of the results of BCA engineering cooperation and design assistance in helping solve problems involving the use of ball bearings on farm equipment. Bring us *your* bearing problems.

BCA

BEARINGS COMPANY OF AMERICA

DIVISION OF FEDERAL-MOGUL CORPORATION

LANCASTER • PENNSYLVANIA

How we opened the door to lower costs for Ford

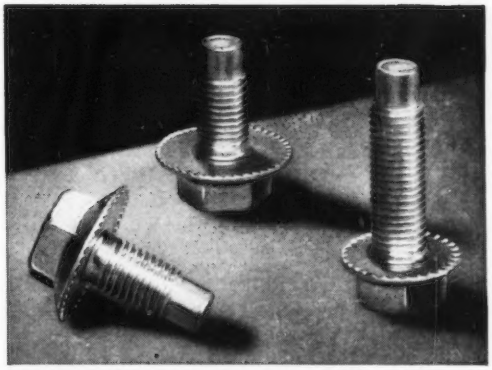
Two hinges on every Ford door. Six screws and 12 washers for each hinge.

Did this present an opportunity for cost reduction? An RB&W "fastener engineer" thought so. And after careful analysis and time studies Ford engineers agreed.

The solution: RB&W Hex SPIN-LOCK screws to fasten the hinge to the door, eliminating the need for washers. And special wide-flange Hex SPIN-LOCK screws for attaching the hinge to the frame, doing away with more washers. The wide flange is necessary to cover an elongated hole in which the hinge moves to permit accurate alignment.

Result — parts requirements are cut by two thirds, assembly is simplified, purchasing and inventory costs are lowered. And RB&W SPIN-LOCK screws hold those door hinges tight for good.

We will be glad to send an RB&W man around to check up on your fastening operations. Every problem is different, of course, but RB&W has a fastener for just about every job. If you need a "special", as Ford did, we'll design and make it for you. Write RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY, Port Chester, New York.



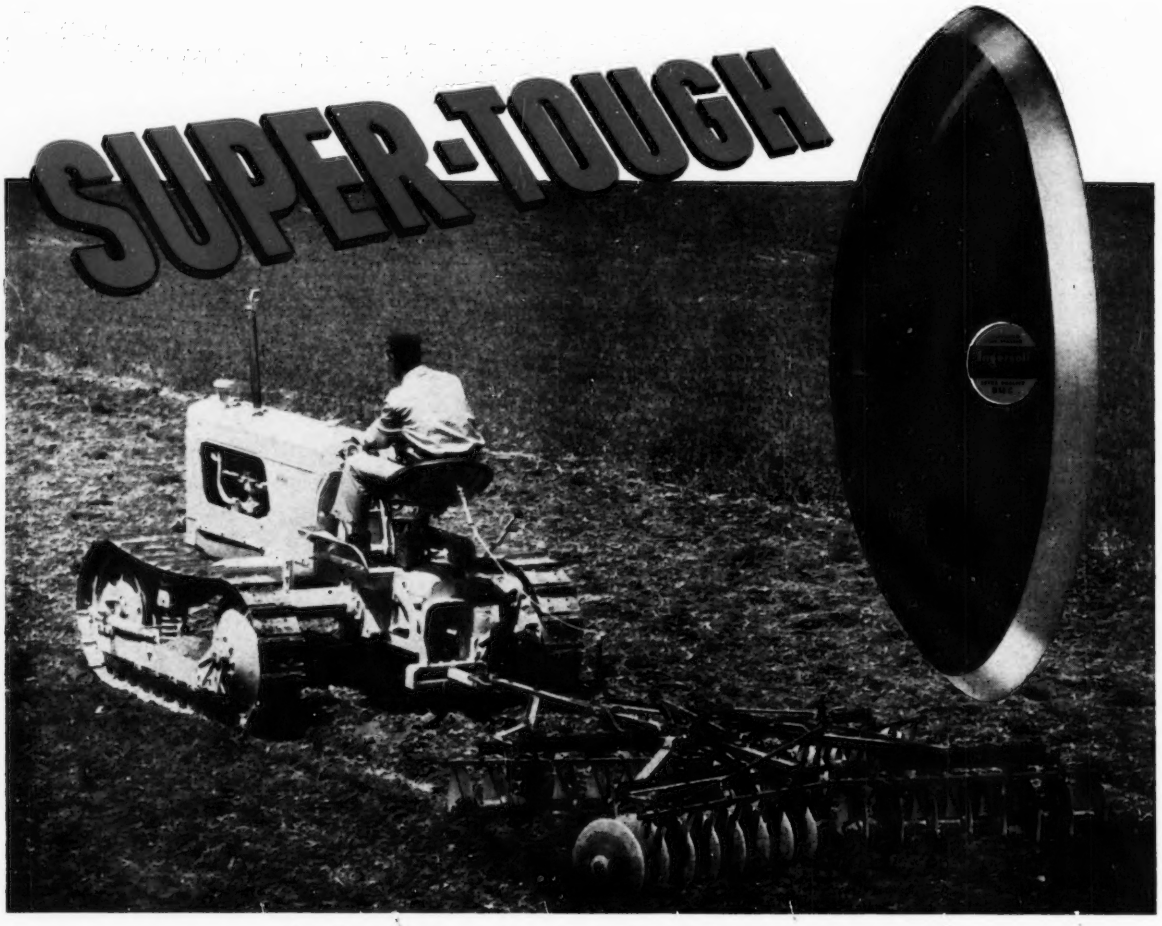
FASTER ASSEMBLY, reduced costs were the pay-off, using RB&W designed wide-flange SPIN-LOCK screws (left) for door hinge. Other SPIN-LOCKS (right) hold hinge on door. SPIN-LOCK screws *can't loosen* because ratchet-like teeth lock into surface and hold tight.

3.10

RB&W

109 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

Plants at: **PORT CHESTER, N.Y.; CORAOPOLIS, PA.; ROCK FALLS, ILL.; LOS ANGELES, CALIF.** ***Additional sales offices at:*** **ARDMORE (PHILA.), PA.; PITTSBURGH; DETROIT; CHICAGO; DALLAS; SAN FRANCISCO.** ***Sales agents at:*** **PORTLAND, SEATTLE.** ***Distributors from coast to coast.***



Oliver OC-6 Tractor, pulling a PA-8 Disc Harrow, equipped with Ingersoll Heat Treated Discs

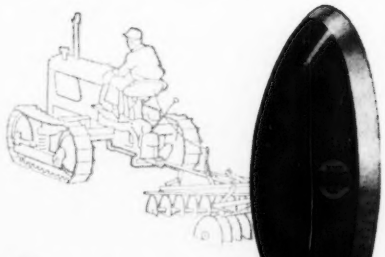
for TOP PERFORMANCE, LONG LIFE

There's this about every Ingersoll disc . . . from start to finish, *super-toughness* is built right into it—for top performance, long life, extra acres of work.

Take the steel it's made of . . . Ingersoll's special TEM-CROSS ® tillage steel. *Cross*-rolled for maximum resistance to splitting and curling at the edges, and to withstand the impact and shock of hard field use.

Take Ingersoll's exclusive heat treating process. That's what assures proper hardness in Ingersoll's discs, provides greater uniformity, eliminates warping, reduces stress and strain from center hole to edge, adds extra toughness and resistance to abrasion. Take Ingersoll's quality control—every disc manufactured to rigid standards to assure the finest quality possible.

When your implements are equipped with Ingersoll discs, you can be sure these discs are *super-tough*—for real satisfaction to your customers.



Ingersoll
Heat Treated Discs

INGERSOLL PRODUCTS DIVISION
Borg-Warner Corporation
310 South Michigan Avenue • Chicago 4, Illinois
SPECIALISTS IN TILLAGE STEEL • WORLD'S LARGEST MANUFACTURER OF DISCS

ENGINEERING B-W PRODUCTION

Other Agricultural Products:
Spring Teeth for Harrows and Cultivators
Coil Spring Shanks

AGRICULTURAL ENGINEERING

VOL. 35 NOVEMBER, 1954 NO. 11

The Small Watershed

J. C. Dykes
Member ASAE

Expanded Program Offering New Challenges and Opportunities for Many Agricultural Engineers and Involving Many Aspects of Engineering

I DO not consider the small watershed program as a completely *new* job for agricultural engineers. Rather, let us say that this program offers new and expanded opportunities and new challenges for the agricultural engineers of the nation. Many engineers working on watershed programs will be confronted with problems that are new to them. These will be problems in geology, sedimentation, hydraulics, hydrology, engineering design, construction, soil physics, and so on to be solved in the expanding small watershed program.

Nor is the small watershed program really a new program to the Soil Conservation Service, since a considerable part of the soil and water conservation program has always involved the watershed concept. It has gained new prominence recently because of increased appropriations by the Congress for this specific type of work. In 1953 Congress provided funds for a "pilot plant" program which is now in its second year with about 60 projects in 33 states—projects that range in size from 2500 to 250,000 acres. This program is providing some worth-while guide lines to our future operations under the Watershed Protection and Flood Prevention Act, Public Law 566-83rd Congress, commonly known as the Hope-Aiken Bill, which was passed by Congress and approved by the President on August 4 of this year.

Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Burlington, Vt., August, 1954.

The author—J. C. DYKES—is assistant administrator, field services, Soil Conservation Service, U.S. Department of Agriculture.

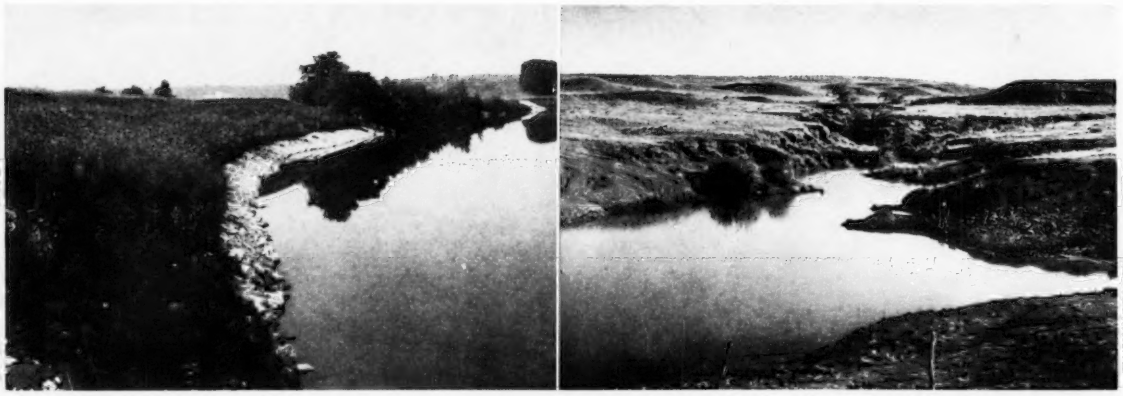
First, let us examine this new watershed act. Its primary objective is to provide a basis for cooperation between local watershed groups and the federal government in solving their watershed problems. Federal aid is given, however, only where local groups desire and request such aid and are able and willing to do their share of the watershed protection work.

Where water problems, such as floodwater or sediment damage, drainage, or irrigation, are major problems in a watershed, they are usually of such magnitude and importance that their solution is an essential part of the solutions of most other conservation problems. In such watersheds the local farmers and ranchers usually need and seek aid on their common water problem or problems. The Watershed Protection and Flood Prevention Act provides a simple, practical way for the federal government to provide such assistance to local groups with the minimum of delay.

The needs and interests of the people who live in the watershed are indeed paramount under the Act. Any action taken must be initiated by the local people, since the Act authorizes the Secretary of Agriculture to render assistance only on a state-approved application from a local sponsoring organization.

If federal assistance in planning is made available, the local sponsoring organization must participate in each step of the planning in order (1) to keep their needs and desires in the forefront, and (2) so that the group may understand the technical requirements of control measures proposed by

(Left) Good bottom land protected by floodwater-retarding structure in Sandstone Creek Watershed, Upper Washita Soil Conservation District, Oklahoma • *(Right)* A small floodwater-retarding structure in a pasture near Hammon, Okla. Cultivated land is terraced and contour tilled



(Left) Rock riprap supplemented by a band of vegetation above to control stream-bank erosion on the Winooski River, Vermont • *(Right)* A sediment storage pool in a rough gullied area. The county built the dam to replace an old wooden bridge on the county road, Washita Flood Prevention Project, Oklahoma. Counties and other local political subdivisions often participate in small watershed treatment

the assisting agencies. The watershed work plan required under the act must be prepared in closest cooperation with the local people and thoroughly supported by them as their plan.

When the jointly developed, mutually acceptable physical plan is completed, the local sponsoring organization must be in a position to make a definite proposal to the Secretary of Agriculture (1) setting forth the share of the cost that will be met from non-federal sources, and (2) requesting the Secretary to make available the necessary federal resources to supplement those supplied from state and local sources. The act requires that local people acquire all necessary land easements and rights-of-way; operate and maintain the works of improvement on non-federal land, and share equitably in the cost of installation on the basis of anticipated benefits.

In most cases prior to July 1, 1956, and in all cases thereafter, the local sponsoring organization will contract for the necessary watershed structures. In addition, the cost of supplemental works for purposes not set forth in this act, such as storage of water for irrigation or for municipal or industrial use, must be fully paid for from non-federal sources.

The state governments have a key position in helping their local people take advantage of the opportunity provided by the Act. State funds may well be used to help cover part of the required non-federal costs. In many cases state agencies can make their own programs more effective by close coordination with the watershed programs. All states will probably review their existing special purpose district enabling legislation in the light of the local participation requirements of this Act. Many states may decide to pass new enabling legislation or to amend existing legislation in order to facilitate work under this Act. The responsibility for meeting the requirements of state water rights and control laws rests squarely with the local people.

The great interest in the watershed protection and flood prevention program and the number of applications that are already being received or being prepared under it, only emphasize the desirability of local people doing all that they can to help themselves and asking the Federal government to supplement their resources with only that part they cannot provide themselves. The cost-sharing requirements as set forth in the Act are truly a floor; they should in no sense be interpreted as a ceiling on the portion of the costs to be borne by the local interests. The greater the share of the cost that they can and will assume, the better their opportunity to receive the assistance they need to carry through the project.

Emphasis is on local initiation, local participation in planning, local cost-sharing, local contracting, local operation and local maintenance of the works of improvement and on the federal share being only that portion of the work the local interests cannot meet with the resources available in the watershed and the state.

The Soil Conservation Service has been designated by the Secretary as the primary watershed activities agency of the Department of Agriculture. As such the SCS will accept applications from local organizations for assistance in planning a watershed program. In view of the existing agreements between the Department and soil conservation districts, and the inter-relationship between the required land-treatment measures and other phases of the watershed program, applications will usually be sponsored or co-sponsored by soil conservation districts, where such districts exist. In watersheds where soil conservation districts have not yet been formed, the application must include complete information on how the land-treatment measures will be planned and applied.

Now to consider further the matter of expanded opportunities for agricultural engineers. As is true in any other line of activity, the real progress will be made by those engineers who best prepare themselves to cope with the engineering problems inherent in the program. As stated before, few of the problems will involve new principles. Many, however, will be new to agricultural engineers because of the degree of complexity.

In our assistance to districts many of our hydrologic determinations have centered around the peak rate of runoff to be expected at a given point. They must now be broadened to include both rate and volume of runoff as well as the effect of one structure upon another and of a system of structures and measures in retarding waterflow in the watershed as a whole. This will require a more exacting application of the fundamentals of hydrology than has been required in much of our past work. For many of the practicing agricultural engineers this will require self-improvement

in the subject of hydrology. The agricultural engineering student would do well to include more of this subject in his course of study.

Hydraulics is another science that will have wide application in the small watershed program. In addition to the relatively simple gradient-control structures, there will be a wide variety of hydraulic problems including water-routing and waterflow-retardation structures, each requiring the application of rather complex hydraulic principles.

In his day-to-day activities the agricultural engineer engaged in the small watershed program will encounter problems in structural engineering. These problems will involve the design of structures of reinforced concrete, timber, steel, and earth. The very nature of the program, with emphasis on maximum accomplishments with minimum costs, requires that the greatest use consistent with engineering soundness must be made of readily available material. Adequate training in structural design will be a requirement for the engineer engaged in watershed work.

A rather broad knowledge of mechanics will be needed. The requirements in this field will not differ greatly from the civil and mechanical engineering courses in mechanics which are normally required for a degree in civil engineering.

A knowledge of engineering contracts will also be important. Even though local sponsoring organizations will contract for the necessary watershed structures in most cases, they will still look to the Soil Conservation Service for guidance in the preparation of specifications to insure acceptable work by contractors and to avoid also the inclusion of requirements that would be unreasonable and impractical from the standpoint of performance by the contractor.

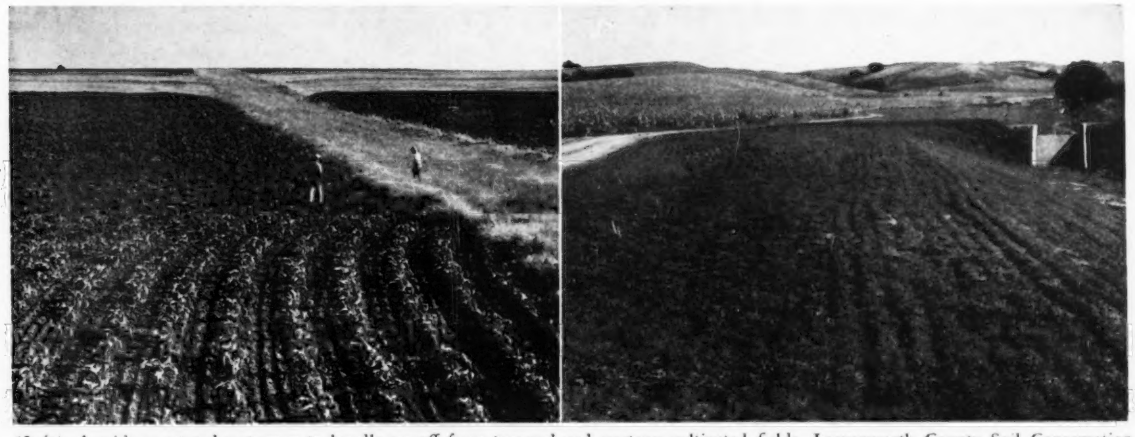
A high degree of skill in the planning and making of engineering surveys will be required. Accurate topographic maps are essential in the location and design of waterflow-retardation structures. Representative profiles and cross sections will be used for hydrologic studies and for the proper location of all structures. Inaccuracies in the basic surveys could result in the development of an unsound plan or in failure of the applied watershed program to function as anticipated. Considering the importance of this phase of engineering the student agricultural engineer would be wise to include advanced courses in surveying in addition to plane surveying.

The watershed work plan developed for each small watershed will recognize the needs for drainage and irrigation improvements, where such needs exist. The general courses normally offered in these subjects may well be supplemented with a few hours of advanced work.

Training in soils and farm crops will be just as important for the engineer in the small watershed program as it is in his activities in other soil and water conservation work. It would be to the engineer's advantage to obtain within practical limits all the information possible on soil physics. Much of his work will require knowledge of the relations between soil structure, infiltration, permeability and stability. A good working knowledge of soil mechanics also will be invaluable in his earth embankment work.

It is expected that trained geologists will be available to assist on all complex problems involving that subject. However, the engineer will be able to perform more efficiently if he has had at least an introductory course in geology. He will be better able to recognize the surface indications of formations which might cause difficulty. This would make it possible to call in the geologist in the early stages of planning and thereby avoid changes in structure plans later.

It is noted that increased demands for engineering assistance in irrigation, more recently in the humid areas, drainage and water development all indicate the need for training similar to that required by engineers engaged in watershed work. An agricultural engineer who has adequate training along the lines just discussed should be prepared for a very successful career in the Soil Conservation Service. The SCS has long been one of the big users of agricultural engineering graduates. Over three-fourths of our current engineering staff of approximately nine hundred are agricultural engineers. The growing importance of the watershed activities points to an expanding staff of engineers. While some engineering specialists will be included, it is hoped the colleges and universities will recognize the changing needs of the agricultural engineering graduates and that the Soil Conservation Service can employ them in even greater numbers than in the past.



(Left) A wide vegetated waterway to handle runoff from terraced and contour cultivated fields, Leavenworth County Soil Conservation District, Kansas • *(Right)* A stabilizing structure in a gully that has been shaped and seeded, Monona County, Iowa

Equilibrium Moisture and Heat of Vaporization of Shelled Corn and Wheat

H. J. Thompson and C. K. Shedd
Member ASAE Life Fellow ASAE

THE experimental data used in this paper were obtained in an experiment conducted by the senior author, then junior agricultural Engineer at the USDA Plant Industry Station, between 1939-1941 and reported in an unpublished report dated July, 1941. Determinations were made of the moisture content of grains that had come to moisture equilibrium in atmospheres of various constant humidities at four different constant temperatures.

This experiment makes some worth-while additions to available information on equilibrium moisture content of grains, but the most important value of the results lies in the fact that equilibrium moistures were determined at more than one temperature. This makes it possible to calculate the heat of vaporization of moisture from the grain. It is well known that somewhat more heat is required to evaporate a pound of moisture from grain than to evaporate a pound of free water, but there has been no precise information available as to the amount of this additional heat. From the data obtained in this experiment, heats of vaporization can be calculated for shelled corn and wheat. The calculated values may not be as precise as we would like, and they cover only a rather narrow range of grain moistures; but they are believed to be useful until more precise and complete data are obtained.

Calculation of Heat of Vaporization.

In this paper, the Othmer* method of calculating heat of vaporization is used. Othmer found that a straight line is obtained by plotting on log-log paper vapor pressure of the liquid under investigation (moisture in the grain in this case) against vapor pressure of a reference liquid (water) at the same temperature. He developed the following equation:

$$\log P = \frac{L_v}{L_{vr}} \log P_r + C$$

in which P = vapor pressure of moisture in the grain that has reached a constant weight when exposed to a given psychrometric condition. (At this condition the vapor pressure of the moisture in the air and the moisture in the grain are equal.)

P_r = vapor pressure of water

L_v = heat of vaporization of moisture from grain

L_{vr} = heat of vaporization of water

C = a constant.

P, P_r, L_v, and L_{vr} are to be taken at the same temperature.

L_v/L_{vr} is the slope of a constant grain moisture content line in the Othmer graph.

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The authors — H. J. THOMPSON and C. K. SHEDD — are, respectively, agricultural engineer and formerly senior agricultural engineer, farm building section, agricultural engineering research branch (ARS), U.S. Department of Agriculture.

*Chemical Engineers' Handbook, second edition, 1941, pages 640 and 733.

Grains Used

The grains used in this test are listed in Table 1. The corn was yellow dent corn from College Park, Md., and the wheat was soft, red winter wheat from the same station. The initial moisture contents were measured after pretreatment of duplicate samples to furnish both high and low moisture content grains for each psychrometric test condition. This procedure was used to estimate the effect of initial moisture content upon the equilibrium moisture content. Thus it was planned to neutralize the effect of initial moisture content upon final moisture content.

TABLE 1. GRAIN SAMPLES FOR EACH STORAGE CONDITION

Grain	Crop	Number of samples*	Initial moisture** High	Low
Ear corn	1938	2	16.6 %	8.6 %
Ear corn	1939	4	16.6	7.9
Shelled corn	1939	2	16.6	7.9
Wheat	1938	2	21.0	9.0
Wheat	1939	2	22.8	8.9

*Individual ears of corn were used as samples, all other grain samples weighing about 100 g each.

**Measured percent moisture of grain after pretreatment to bring one-half of the samples to a high moisture content and the other half to a low moisture content. Ear corn values are those of grain only.

Exposure of Samples

After pretreatment, corn and wheat samples for each storage condition were exposed in a confined atmosphere above a saturated salt solution in a 5-gal jar. After the grain samples had reached constant weight, the vapor pressure of air exposed to grain and salt solution surfaces was determined by the use of wet and dry thermocouples at 70, 50 and 32 F. At 20 F the vapor pressures were determined from known vapor concentration properties of sulphuric acid under equilibrium conditions. Small amounts of acid were exposed directly to the atmospheres within the test jars at 20 F. Table 2 gives a description of the various conditions and time of exposure of samples. The closed jars containing the grain and salt solutions were exposed within constant-temperature rooms; a full set of jars in each of four constant-temperature rooms were maintained respectively at 20, 32, 50 and 70 F.

TABLE 2. STORAGE CONDITIONS

Temp., deg F	Salt*	RH, %	Days
70	NH_4Cl	75	219
70	NaCl	73	209
70	$Ca(NO_3)_2$	55	218
70	$CaCl_2$	35	218
50	NH_4Cl	81	252
50	NaCl	75	244
50	$Ca(NO_3)_2$	59	251
50	$CaCl_2$	40	251
32	NH_4Cl	83	424
32	NaCl	77	419
32	$Ca(NO_3)_2$	64	424
32	$CaCl_2$	41	423
20	NH_4Cl	82	441
20	NaCl	74	446
20	$Ca(NO_3)_2$	64	440
20	$CaCl_2$	44	440

*Saturated salt solution used to maintain various humidities after grain had reached constant weight.

Moisture Determinations

Moisture contents were determined from weights made before and after drying samples in a vacuum oven held at 80 C and a vacuum of about 25 in of mercury for a period of six days. The analytical balance was sensitive to 1 mg. The moisture samples of about 30 g each were dried and weighed in ointment tins of about 100-cc capacity. Duplicate moisture samples were taken from the grain shelled from ear corn; single samples being used for the cobs and wheat. Moisture determinations by the methods of this test were compared with measurements on duplicate samples made as specified in the official grain standards of the United States.† Test and official determinations agreed well within one-half percent wet basis for wheat samples at about 13 and 19 percent moisture and corn samples at 7 and 18 percent moisture. However, due to the small amount of grain available for sampling and the equipment at hand, the official grain standards method was not used for testing.

Final Condition of Samples

The initial treatment to provide duplicate samples, one above and one below equilibrium moisture content, had an effect on final moisture. The initially high moisture sample had a higher equilibrium moisture content than the initially dry sample. The differences are recorded in Table 3. In plotting Figs. 1 and 3, the equilibrium moisture content used was the average indicated for the initially wet and initially dry samples.

TABLE 3. AVERAGE DIFFERENCE IN FINAL PERCENT MOISTURE DUE TO INITIAL TREATMENT*

Grain	Temp., deg F	Percent relative humidity ranges 75 - 82	73 - 76	55 - 66	35 - 44	Avg.
Corn**	70	0.10	0.70	0.41	0.55	0.44
	50	0.17	0.75	1.37	0.45	0.68
	32	0.22	0.75	1.75	1.53	1.02
	20	0.28	0.37	1.30	1.67	0.90
	Avg.	0.19	0.64	1.21	1.05	0.77
Cobs	70	0.80	1.42	0.59	0.23	0.76
	50	0.58	1.24	1.25	0.40	0.87
	32	0.28	1.03	1.94	1.83	1.27
	20	0.51	0.71	1.98	2.16	1.34
	Avg.	0.54	1.10	1.44	1.16	1.06
Wheat	70	0.20	0.33	0.50	0.08	0.28
	50	0.00	0.48	0.82	0.62	0.48
	32	-0.13	0.18	1.03	1.39	0.62
	20	0.08	0.18	1.00	1.69	0.74
	Avg.	0.04	0.29	0.84	0.94	0.53

*Initially high-moisture-content samples minus initially low-moisture-content samples.

**Corn shelled from all ears having reached constant weight.

No breakdown or molding occurred in any of the corn samples. Wheat grown in 1938 and predried before exposure to 50 F and 81 percent relative humidity for 306 days was slightly moldy whereas the sample premoistened before exposure was moldy. Wheat grown in 1939 and treated in the same manner gave no molding on the predried sample and only slight mold on the premoistened sample.

†The authors are indebted to Alfred Christie and Harry B. Dixon, formerly of the Bureau of Agricultural Economics, U.S. Department of Agriculture, for making the official measurements.

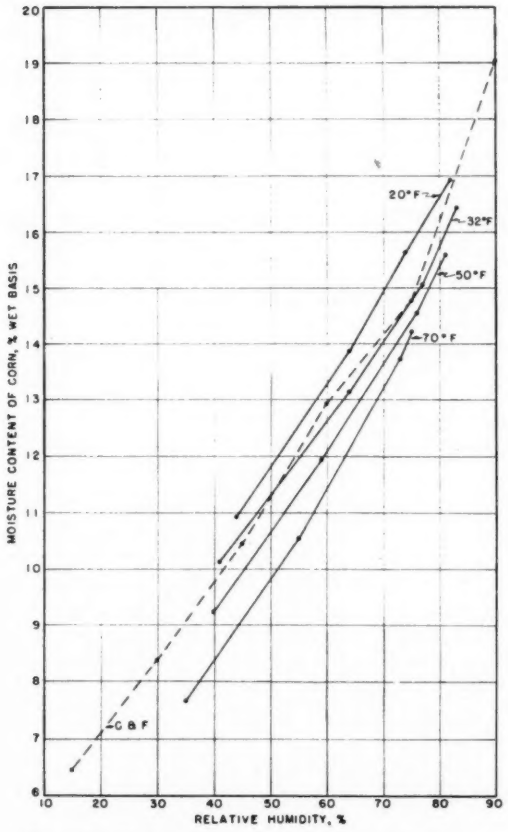

Fig. 1 Equilibrium moisture of shelled corn (Thompson)

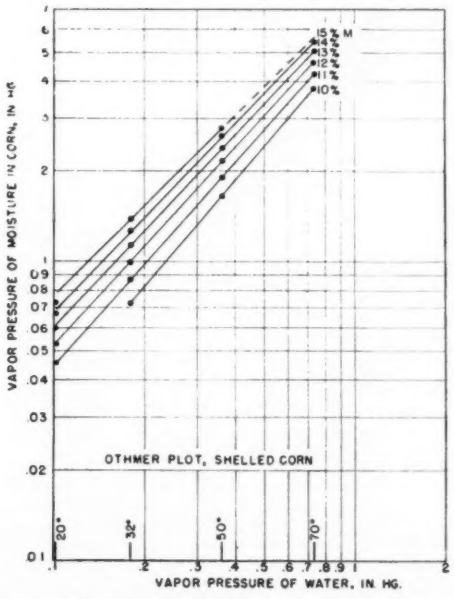

Fig. 2 Othmer plot of shelled corn data shown in Fig. 1

TABLE 4. HEAT OF VAPORIZATION OF MOISTURE FROM SHELLED CORN

Material	$\frac{L_v}{L_{vr}}$	Temperature of evaporation, deg F				
		32	50	70	100	150
		Heat of vaporization, Btu per lb				
Water		1075	1065	1055	1037	1008
Corn						
10% moisture	1.175	1265	1250	1240	1220	1180
11% "	1.130	1220	1210	1200	1180	1140
12% "	1.095	1175	1165	1155	1135	1105
13% "	1.065	1145	1135	1125	1105	1070
14% "	1.040	1120	1110	1100	1080	1050
15% "	1.020	1095	1085	1075	1055	1025

TABLE 5. HEAT OF VAPORIZATION OF MOISTURE FROM WHEAT

Material	$\frac{L_v}{L_{vr}}$	Temperature of evaporation, deg F				
		32	50	70	100	150
		Heat of vaporization, Btu per lb				
Water		1075	1065	1055	1037	1008
Wheat						
11% moisture	1.16	1250	1240	1225	1200	1170
12% "	1.12	1200	1190	1175	1155	1120
13% "	1.08	1160	1150	1140	1120	1090
14% "	1.05	1130	1120	1110	1090	1060
15% "	1.03	1110	1100	1090	1070	1040

Results

The moisture equilibrium determinations are shown in Fig. 1 for corn and Fig. 3 for wheat. The dotted line in each of these charts shows Coleman and Fellows data published in an article, entitled "Hygroscopic Moisture of Cereal Grains and Flaxseed Exposed to Atmospheres of Different Relative Humidity," *Cereal Chemistry,* September, 1925. Relative humidity, temperature and previous moisture content all affect the equilibrium moisture content of corn and wheat under normal atmospheric conditions. Other factors remaining constant, a 7 percent rise in relative humidity will raise the moisture content about 1 percent, a 50 F drop in temperature will increase the moisture content about 2 percent and predrying to 8 percent moisture will decrease the equilibrium moisture content from 0.5 to 0.8 percent in comparison with samples premoistened to 16 percent moisture.

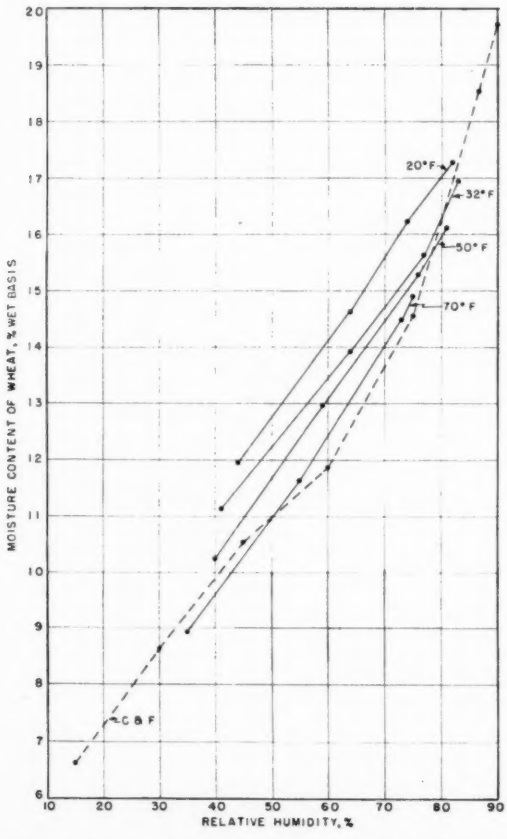

Fig. 3 Equilibrium moisture of soft red winter wheat (Thompson)

Fig. 2 is an Othmer plot of the corn data shown in Fig. 1. Interpolation was necessary to secure vapor pressure curves for grain at a constant moisture content throughout the temperature range.

Relationships between moisture content and relative humidity at various temperatures are for shelled corn, corn shelled after exposure, and cobs from test ears shown in Figs. 4 and 5.

The results of calculations of heat of vaporization are recorded in Table 4 for corn and Table 5 for wheat. Values for 100 and 150 F were obtained by extrapolation of the straight line in the Othmer graph. As grain moisture content increases the value of heat of vaporization approaches that for free water.

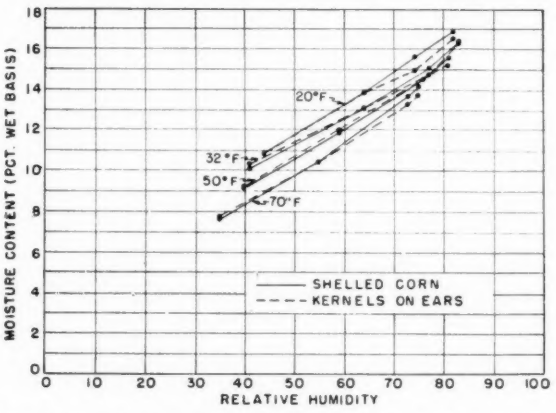

Fig. 4 Percent moisture in shelled corn having reached constant weight

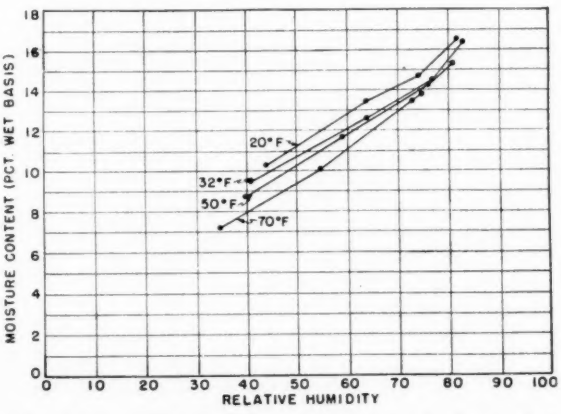

Fig. 5 Percent moisture in corncobs from ears having reached constant weight

Tractor Hitches and Hydraulic Systems

Bruno B. Johannsen
Member ASAE

The Best Solution of Design Problems Requires Close Cooperation Between Tractor and Implement Designers

IMPLEMENT hitches and hydraulic systems provided with present-day agricultural tractors are in general designed by the tractor manufacturer's engineering group. These designs usually represent the tractor designer's idea as to what is required to operate a variety of implements properly, and may not necessarily be the best design to operate successfully a particular type of implement produced by an implement manufacturer.

Transferring the tractor-hitch design to the implement designer will also present problems in that the implement designer is not entirely familiar with tractor limitations; and further, even though the men in this design group are familiar with the specific requirements of their own particular implements, they do not always fully understand the problem peculiar to other implements. In present day circumstances, farmer customers usually expect one make of implement to function successfully with a number of different makes and models of tractors and *vice versa*. It therefore appears that a satisfactory design of hitch and hydraulic system must be reached as a result of close cooperation between tractor and implement designers so that individual design problems and limitations may be mutually understood.

The purpose of this paper is to present the implement designer's problems in the hope that future tractors may have hitches and hydraulic systems which will more nearly fit the field requirements.

Since World War II, integral implements have become increasingly popular. Their ever-increasing popularity over the corresponding towed type can be attributed to the following factors:

A Greater Maneuverability of Tractor-and-Implement Combination

With the use of integral implements, the farmer can successfully work small or irregularly shaped fields that are often impossible or impractical to work with a drawn implement. Integral tillage tools, planters, and cultivators can be readily lifted and backed into corners or hard-to-reach places, whereas it is rather difficult to back up with drawn equipment. This also applies to scoops, blades, and like implements when used for moving materials and making fills around farm buildings.

B Better Transporting Characteristics of Tractor-and-Implement Combination

In the past twelve years there has been a great influx of farm labor to the cities to work in industrial plants. The result is that farmers are now farming more land, and farming land at greater distances from their homes. Modern tractors equipped with rubber tires and transport speeds of 10 to 20 mph offset the greater distances. Customers, therefore, desire integral implements that can be transported safely at the higher transport speed of the modern tractor. It is also recognized that the number of hard-surfaced roads over which farmers must transport implements are steadily increasing. Generally it is essential that the implement be kept from contact with the road surface to prevent damage to the implement, the road surface, or both.

C Lower Cost Implements

Integrally mounted implements can normally be sold at lower cost due to the fact that wheels, raising and lowering mechanisms, lateral and longitudinal adjustments, as well as depth-gaging means, are eliminated from the cost of each individual implement since they are furnished as a part of the tractor. The cost, when applied to the tractor, is therefore spread over a number of implements. Let us consider the comparative weight and cost of a drawn moldboard plow with mechanical lift, a hydraulically controlled drawn plow, and an integral plow each in the two-bottom 14-in size. Basing the cost of the two-bottom drawn plow with mechanical lift at 100 percent, the retail cost of a hydraulically controlled towed plow is 93.7 percent and the integral plow is 58.7 percent of the mechanical lift plow. In times of a buyer's market, the lower price tags on the integral implements are attracting more and more attention.

D Ease of Attachment and Control

Integral implements lend themselves to a design such that the implement can be readily attached or detached, in many cases, without the necessity of leaving the tractor seat. Such implements are readily adjusted for longitudinal and lateral leveling from the tractor seat.

Although the features listed above have made integral implements popular, it must be recognized that there are limits to which integral implements can be used and that drawn implements will continue to be in demand. A drawn implement is universally adaptable to all makes and models of tractors equipped with a drawbar and a suitable hydraulic system for operating a remote cylinder on the implement. The single point of attachment consisting of a clevis and a pin makes it easy to attach or detach most drawn implements. Optimum-size drawn implements can utilize the full tractor power. This is particularly true for such implements as disk harrows, spike-tooth harrows, rotary hoes, disk tillers, etc. If soil penetration is a problem, added ballast can be applied to a drawn tool whereas such practice is often prohibitive on integral tools because of limitations of the tractor's hydraulic lift capacity or the possibility of adversely affecting the tractor's stability. In the wheat-growing states, multiple-drawn tool operation is popular as it permits full utilization of both available time and labor. Tools commonly used in multiple hookup are tool-bar cultivators and rod weeders, grain drills and rod weeders, rod weeders and drag harrows, and tool-bar cultivators with drag harrows. With such multiple-tool arrangement, farmers are able to farm more acres with less manpower, but they are not feasible with integral tools as we know them.

It is also recognized that drawn implements are not thrown out of adjustment when they are attached to or de-

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tached from a tractor. Untrained tractor operators frequently employed by farms, ranches and plantations, can successfully operate a variety of drawn tools interchangeably after each tool is once properly adjusted for the field condition. On the other hand, integral tools normally require separate hitch adjustment for each type of implement for satisfactory performance. To adjust an integral tool properly each time it is attached to a tractor is, in many cases, beyond the scope of an untrained tractor operator, therefore requiring the close attention of a field supervisor. To place these adjustments in each implement would probably inflict a cost penalty that could not be tolerated.

The popular performance features that have been incorporated in drawn tools throughout the years will continue as

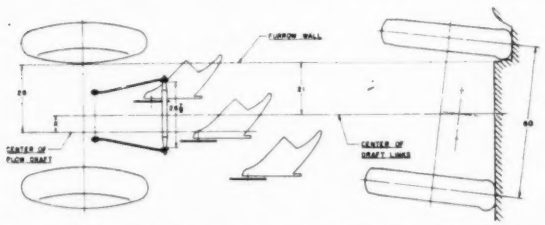

Fig. 2 Implement and tractor alignment (three-bottom, 16-in plow, 26⅞-in crossbar, 10-in tires at 60-in tread)

popular features in integral tools. Although in some cases the customer has demonstrated a willingness to sacrifice somewhat in the quality of the work done to obtain the advantages of integral tools, this sacrifice is made not because he likes to make it, but because in many cases he is obliged to yield an advantage in order to gain other advantages integral tools might offer.

The following list of performance features should therefore be given consideration in the design of the implement hitch and hydraulic system in order to make integral equipment more popular or more readily acceptable to the consumer:

A Provision for Interuse of Competitive Implements and Tractors

The standardization activities of the SAE and ASAE have established dimensional relationships whereby this is successfully accomplished with drawn implements using either a tractor drawbar, a tractor power take-off, or the double-acting remote cylinder of the tractor hydraulic system. It appears also desirable to secure the same provisions for integral implements using a common hitch. To accomplish this desirable result, the farm-equipment industry should make available the following information:

1 Dimensional relationship of points of implement attachment

2 Arc of travel provided at points of implement attachment by the tractor hydraulic system

3 Precautions that implement manufacturers must take to secure proper functioning of depth control means provided in the hitch

4 Permissible loads that can be safely applied to the hitch.

The 3-point hitch, which uses a crossbar length of 26⅞ in, is satisfactory for a 2-plow tractor; however, this is not the most satisfactory length for a plow in the 3-bottom size. The center of draft of a 2-bottom plow, of 14-in width per bottom, is approximately 17½ in from the furrow wall.

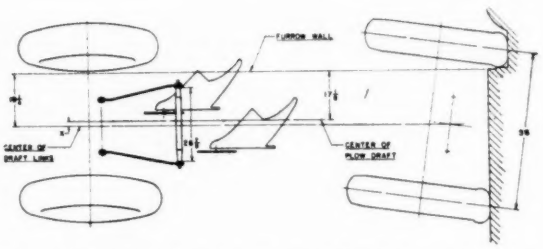

Fig. 1 Implement and tractor alignment (two-bottom, 14-in plow, 26⅞-in crossbar, 10-in tires at 56-in tread)

Allowing for the tilt of the tractor when operating with the right wheel in a furrow, a tractor equipped with 10-in rear tires set at 56-in tread, permits the draft links to be centered on the tractor and provides satisfactory clearance between the front rolling coulter and the right draft link on turns. The center of plow draft is approximately 1¾ in to the right of the center of the draft links which is not considered objectionable. This type of hitch hookup is shown in Fig. 1. A 3-bottom plow, 16-in width per bottom, equipped with a 26⅞-in crossbar is shown in Fig. 2. Here the tractor wheel tread is increased to 60 in to retain the draft links centered on the tractor in the working position and also retain working clearance for the front rolling coulter. The center of draft of a 3-bottom 16-in plow is approximately 28 in from the furrow wall. This results in the line of draft of the plow being approximately 7 in to the left of the center of the draft links and sets up a horizontal component which produces side draft on the tractor and results in difficult steering.

Our experience has been that a crossbar 32½ in long, rather than 26⅞ in as shown by Fig. 3, permits attaching a 3-bottom 16-in plow in a more favorable position behind a 3-plow size tractor so that the center of draft of the plow can be more nearly aligned on the center of the tractor draft links thereby reducing side draft on the tractor. Having a center-of-plow draft slightly to the left of the tractor draft links is often a desirable feature as it compensates for the natural tendency of the tractor to run to the right due to the tractor-weight transfer and caster action of the front wheels resulting from the right side of the tractor being low. In addition, the 32½-in crossbar has several other advantages

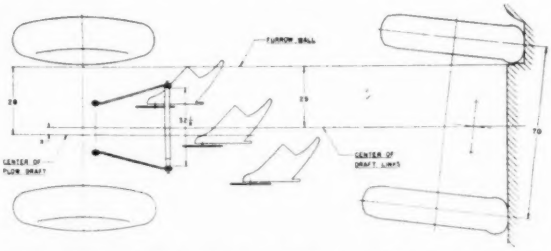

Fig. 3 Implement and tractor alignment (three-bottom, 16-in plow, 32½-in crossbar, 12-in tires at 70-in tread)

over the 26⅞-in bar on the larger implements. It permits attaching a moldboard plow close to the tractor, provides clearance for the front rolling coulter, permits plowing at a wider tractor wheel tread setting which in turn improves the tractor lateral stability on hillsides. The long crossbar is favorable to rigid implement frame construction and implement lateral stability.

B Quick and Easy Attachment of Implements

The integral implements on the market today are generally more difficult to attach or detach than corresponding drawn tools. A design which enables one man to attach an integral implement to a tractor quickly and easily and without undue physical effort, is certainly a necessity. Some tractor-hitch designs are such that the tractor driver can attach an implement while sitting in the tractor seat. Such an arrangement is popular with the trade especially where tractor design is such that it is rather difficult for the operator to climb off and on the seat. A 3-point hitch, as it is known

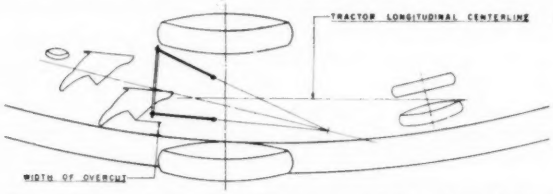

Fig. 4 Trailing characteristic of a plow on a left-hand turn having the hitch point in the horizontal plane located well ahead of the tractor rear axle

today, is quite successfully connected by one man in instances where the implement can be shifted about by hand to make the necessary alignment for attaching the links. Attaching the heavier implements to such a hitch virtually becomes a two-man job. Quick attachable features should be incorporated in the hitch wherever possible.

C Simplicity and Ease of Adjustments

In order to secure optimum performance from both the tractor and the integral implement under varying field and soil conditions, it is necessary that the hitch be in proper adjustment. The adjusting members should be readily accessible and easy to adjust without the aid of special wrenches. They should also be so positioned that the amount and direction of adjustment necessary is readily detected. To help reduce operator confusion, the number of adjusting members should be held to a minimum. All too often a hitch in improper adjustment results in poor implement performance, or heavy implement draft.

D Provision for Fore-and-Aft Leveling of Implements

Most tillage tools such as the moldboard plow, disk plow, and bedder require a relatively close relationship between the angle of the implement and the soil. This relationship is normally established by adjusting the length of the top link, which on some hitches is also a means of depth control. Fore-and-aft leveling is required to take care of manufacturing variation in implement and tractor parts, variation in rolling radius of pneumatic tires, as well as variations in size and type (cane and rice, etc.) of tractor tires.

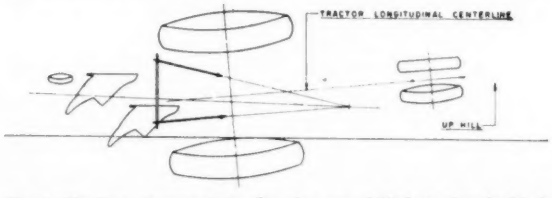

Fig. 6 Trailing characteristic of a plow on a hillsde having the hitch point in the horizontal plane located ahead of the tractor rear axle

Furthermore, a readily adjustable upper link aids in the ease of attaching an implement to a tractor.

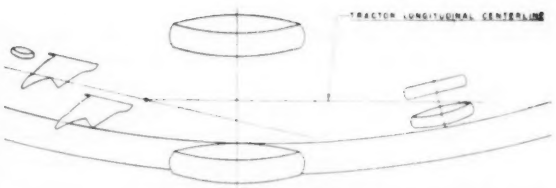

Fig. 5 Trailing characteristic of a plow on a left-hand turn having the hitch point in the horizontal plane located behind the tractor rear axle

E Provisions for Lateral Leveling of Implement

Provision for lateral adjustment of the implement is necessary to take care of manufacturing variations the same as the fore-and-aft leveling discussed above, and, in addition, to provide for the condition where one wheel of the tractor must operate in a furrow for some implements and on level ground for others.

F Provision for Side Sway

To secure the desired trailing characteristic of tillage tools such as plows and tillers, it is necessary that the tool follow the tractor around contours cutting a relatively uniform width without interfering adversely with the tractor steering. Fig. 4 shows a plow having the virtual hitch point in the horizontal plane located well ahead of the tractor rear axle and on the center line of the tractor when moving in a straight forward direction. On a left-hand turn, the plow will overcut and the line from the virtual center of forces of the draft links to the point of resistance of the plow passes to the right of the center of the tractor at the rear axle. It can be seen from this figure that the most favorable performance from this standpoint is secured with the point of convergence of the draft links positioned relatively close to the rear axle of the tractor.

Fig. 5 shows the hitch point of the plow in the horizontal plane located behind the tractor rear-axle center line. Here the plow follows the tractor very well on contours, as the point so located swings in a direction opposite to that which the tractor is turned and thereby aids in maintaining a more nearly uniform width of cut.

In sidehill plowing, the front wheels are usually uphill from their normal position with respect to the furrow, to counteract the tendency of the tractor to drift downhill. Therefore, if the virtual hitch point of the plow is ahead of the rear-axle center line, it will lead the plow uphill to counteract the tendency to undercut or overcut. With the hitch point to the rear of the rear-axle center line, the plow is actually lead in the wrong direction, causing the plow to

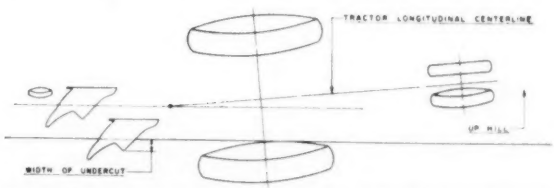

Fig. 7 Trailing characteristic of a plow on a hillside having the hitch point in the horizontal plane located behind the tractor rear axle

overcut or undercut adversely. Figs. 6 and 7 show the effect which the hitch point of the plow has on the trailing characteristics on hillsides. The ease of steering when plowing on a hillside is affected in the same way as it is on contours.

When plowing on a hillside, turning furrows downhill, the tractor and plow will be in the same relationship to each other as if they were plowing on a left-hand contour. The moment arm caused by the off center line of draft makes it difficult to hold the front wheels up the hill or out of the furrow. From this standpoint, a carrier with a large line-of-draft offset will be the most difficult to steer on hillsides and contours.

It appears, therefore, that the best position for the hitch point is near the rear axle and on the tractor center line as this will be a compromise between hillside and contour plowing from the standpoint of controlling width of cut; and, also, there will be no effect on steering from either an offset line of draft or from the tendency of the plow to rotate in a horizontal plane.

G Provisions for the Elimination of Side Sway

It is necessary that implements such as bedders, planters, some types of cultivators, scoops, etc. be locked to the tractor to prevent sidewise movement with respect to the tractor. Therefore, provision should be made to lock the sidesway linkage where required. Furthermore, the implement is transported more satisfactorily, if the sway is restricted.

H Lifting Capacity of the Hydraulic System Must be Adequate

The lifting capacity of the hydraulic system incorporated in most tractors has been developed over the years to meet the requirements of implements in general use. Formerly, however, the hydraulic system of the tractor was used only in raising and lowering implements and not to adjust their working depth. When the hydraulic system is used for depth adjustment as well, capacity must be added for this purpose. In general, approximately 30 percent of the hydraulic-piston travel must be allocated to depth adjustment and as much of the lifting capacity as was previously required for lifting must be continued for that purpose.

As tractors of higher horsepower are gaining in popularity so too will larger implements be required to match the draft capacity of the tractor. These larger integral implements such as the moldboard plow in the 3 and 4-bottom size have considerable length and this large overhang requires a hydraulic system of considerable capacity to raise the implement out of the ground.

I Means for Depth Control

The problems of depth control and depth adjustment, and the means for providing these functions are by far the most difficult of the entire hitch program. Some implements, such as planters, rotary hoes, and spike-tooth harrows, are more or less self-gaging as to depth control and therefore pose no particular problems. Moldboard plows, disk plows, listers, subsoilers and cultivators require depth-gaging means. Furthermore, the operating characteristics of each of these tools are different, and it is therefore difficult to establish one means of depth control that will apply to all. Five basic methods of depth control are in general used with integral tools, as follows:

1 *Suspension of the implement.* By this method, the implement is lowered to a desired working depth by the hydraulic system and suspended from the tractor in this position. The tractor wheels then become the gaging points. This is the simplest method from the mechanical standpoint but has several disadvantages. As the tractor is driven over uneven ground, the implement's working depth varies. If the tractor is operated through a swale, the implement will have a tendency to go deep, and, conversely, if the tractor goes over a hill, the implement will shallow up or come out of the ground.

It is not easy to control the working depth of a rear-mounted tillage tool over uneven terrain, but with a suspended implement the problem is most difficult. A suspended rear-mounted implement operating through a swale and over a hill is shown in Figs. 8 and 9.

2 *Independent depth-gaging means provided on the implement.* This method of depth control is identical to that employed successfully on drawn implements. However, when applied to integral implements, the economic advantage and simplicity are sacrificed. The working depth of the implement must be controlled by changing the gage-wheel setting either by pinning the gage wheel at a selected setting and adjusting the depth through a system of levers, or by adjusting the gaging depth by the hydraulic means which requires a two-function hydraulic system which few tractors presently possess.

3 *Depth gaging by adjustment of suction in the implement.* This method of gaging is used on some hitches especially with moldboard plows which readily respond to suction adjustment. Its principal advantage is its mechanical simplicity since it lends itself to any hydraulic system. In addition, the fore-and-aft leveling means of the hitch can also be used as a means of depth adjustment. Implements so controlled normally vary considerably in working depth when operating over uneven ground or in varying soil conditions. Implements that are relatively short, such as subsoilers and some types of cultivators, do not respond to this method of depth control.

4 *Depth gaging by adjustment of hitch point in a vertical plane.* In this method of depth control, the hitch point is raised or lowered until the implement is working at a desired depth. Although this method is relatively effective, it is not extensively used because the means of accomplishing this adjustment is usually cumbersome and somewhat complicated. A wide range of vertical adjustment is needed to meet the requirements for all implements. The implement using this system usually varies considerably in working depth due to the varying texture of the soil.

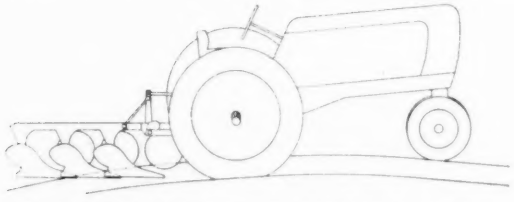

Fig. 8 Suspended implement operating through a swale

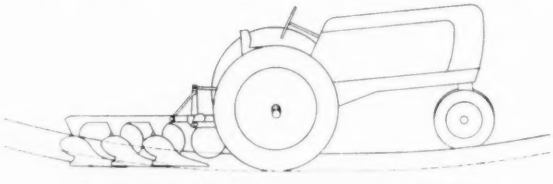

Fig. 9 Suspended implement operating over a hill

5 *Depth control by adjustment by draft or load reaction.* In this method of depth control and adjustment, the implement draft or load is used as a means for gaging the working depth of the implement. It operates on the assumption that the working depth is a function of the implement draft. A force proportional to the implement draft acts through the hitch and is connected by a linkage to the control mechanism of the hydraulic system. The hydraulic system then acts to raise or lower the implement as the load increases or decreases. The hydraulic system may be used to control the working depth by exerting an upward force on the lower links which has the effect of raising the virtual hitch point, or it may also be used to alter the implement suction. In addition, the control linkage may be designed so that the hydraulic system operates to maintain the implement at substantially the exact draft value corresponding to the control-lever setting, or it may be designed to compensate only partially for the implement draft. In the one and two-bottom-plow tractor size, this type of depth control in our opinion has the most appeal. A tractor and implement with this type

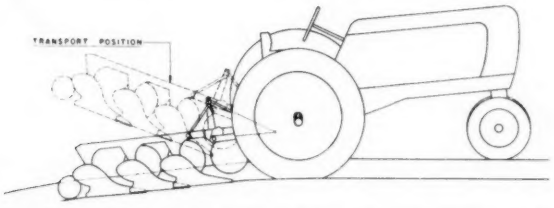

Fig. 10 Hitch point in the vertical plane located near rear-axle shaft

of control can negotiate a very uneven terrain without objectionable variation in the implement working depth where the soil condition is fairly uniform. The tractor can operate through hard or heavy spots in the field without experiencing either traction or power stalls but at a sacrifice of working depth thus giving the tractor operator a feeling of high horsepower reserve.

On tractors having a large horsepower reserve for the size implement, a type control which would hold the implement at a constant working depth might be more desirable than load or draft control.

J Hitch Should Maintain Implement in Proper Relationship to the Ground

The hitch should be of such design that it will keep the implement in proper relationship to the ground under the implement as the tractor and implement are operated over uneven terrain. It is desirable that the working depth through swales and over hills be about the same as the depth on level ground. The hitch should permit the implement to enter the ground to its working position in a relatively short distance as well as to carry the implement at a safe and secure height above the ground in transport.

A hitch point in the vertical plane located near the tractor rear-axle center line as shown by Fig. 10, allows the implement to follow the contour of the terrain through swales and over hills. As the front wheels of the tractor come out of a swale, the attitude of the plow is changed to put more suction in the plow and thereby aiding in retaining plowing depth through a swale. As the front wheels of the tractor pass over a hill, the longitudinal angle of the plow is changed to reduce the suction in the plow and prevent the plow from going too deep. This type of geometry has its objections in that the plow requires longitudinal leveling for various plowing depths because for each change in plowing depth, suction of the plow is also changed. A vertical hitch point so located results in inefficient lifting characteristics, and, in addition, also pitches the rear end of the implement to an awkward angle in the raised position. A hitch point in the vertical plane located well forward of the rear axle as shown in Fig. 11 changes the longitudinal angle of the

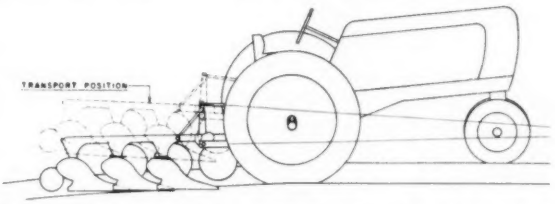

Fig. 11 Hitch point in the vertical plane located well forward of the rear-axle shaft

plow very slightly as the plow moves up or down with respect to the tractor. This action causes a free-floating plow to bridge across swales and plow excessively deep over hills. However, it does permit plowing at various depths without making adjustment in the longitudinal leveling of the plow. Tractors having draft or load-control hydraulic systems usually have such a vertical hitch point, but here the plowing depth is controlled by the tractor hydraulic system.

Therefore, it appears that a compromise must be made in the hitch-point position in the vertical plane for free-floating implements so that the implement may be maintained in the most desirable relationship with the ground, both in working and in the transport positions.

K Provision for Remote Cylinder

With the trend toward tractors of increased horsepower and greater versatility and integral implements of larger size, provision should be made in the tractor for a hydraulic remote cylinder which can be operated independently from and simultaneously with the tractor rockshaft. A remote cylinder can be used effectively in operating gage wheels on implements requiring them, reversing two-way tillage tools, and for controlling drawn tools equipped for remote cylinder operation. In addition, remote cylinders are used extensively for operating front-end loaders, scoops, and cranes around the farm buildings.

L Provide Satisfactory Tractor Longitudinal Stability

To transport the larger or heavier rear-mounted integral tools with safety, adequate weight must be retained on the tractor front wheels so that the tractor can be steered safely over rough terrain or up inclines. Recognizing that rear-mounted pickup tools are here to stay, more tractor front-end weight is required than has been necessary in the past. Some means for readily attaching a reasonable amount of ballast to the tractor front end, when heavy rear-mounted tools are used, should be provided, and yet this weight must be readily removable when implements are mounted on the front of the tractor.

Implement Design Features for Satisfactory Operation

There are a number of implement design features that probably will have to be the responsibility of the individual

(Continued on page 800)

Water Spreading for Storage Underground

Leonard Schiff

A Report of Studies of Recent Developments with Emphasis on Soil Permeability and Size of Areas

WATER is being spread or spreading contemplated in a number of areas to replenish ground-water basins or to develop underground basins as storage reservoirs. The commonly used method for recharge of ground water is to spread water over land. The other method employs pits, shafts, or wells to inject water underground. The objective is to salvage at minimum cost water which would otherwise waste to the ocean and salt lakes or be lost through evaporation and excessive consumptive use.

Increasingly critical ground-water shortages in the San Joaquin Valley of California and many other areas necessitate spreading on soils which do not absorb water rapidly. Soils in these areas generally range from sandy loams to clay loams. Many have hardpan or other nearly impervious layers in the profile. It is often necessary to increase the rate at which such soils absorb water, because of high land values or limited areas, in order to keep water-spreading areas within reasonable limits. Sometimes only a small local overdraft needs replenishing.

Rivers and canals that carry water produced by rainfall and snowmelt, directly or released from storage, are most generally the sources of water for spreading. Sewage and industrial effluents may also provide additional sources of water. In water-shortage areas where large quantities of sewage are being discharged to the ocean, the water overdraft may be relieved more economically by planned sewage reclamation than by importing water or distilling sea water. Industrial expansion also has focused attention on the disposal of effluents, particularly inland developments where disposal on land surfaces or in surface drainages has created problems.

Studies reported in this paper on recent developments in water spreading were conducted by the Division of Irrigation and Water Conservation, Soil Conservation Service Research (USDA), in cooperation with the Kern County Land Company, North Kern Water Storage District, U.S. Bureau of Reclamation, California State Division of Water Resources, and the California Agricultural Experiment Station. The Division of Irrigation completed a laboratory in Bakersfield in 1949 to deal with water-spreading problems involving soil microbiology, soil physics, and hydrology. The laboratory work is concurrent with present water spreading on experimental ponds and large areas. Local wells have been found to reflect recharge from spreading most directly and intensely in order of depth groups 0 to 250 ft, 250 to 750 ft, and over 750 ft.

Terms

The terms used are as follows:

Soil permeability — the rate or readiness with which a soil transmits water.

Infiltration rate or capacity — the rate (feet per day) at which water flowing or impounded at a shallow depth enters the soil at any instant, regardless of cause.

Potential infiltration rate — the rate (feet per day) at which water flowing or impounded at a shallow depth can enter the soil at any instant when conditions beneath the surface do not limit flow.

Percolation rate — the rate (feet per day) of downward flow of water through a depth of soil.

Surface head — depth (feet) of water on the soil surface. Surface head is part of the hydraulic head which motivates flow.

Problem

Typical infiltration-rate curves of Exeter sandy loam or Hesperia sandy loam from a small untreated test pond (0.005 acre) and a large area (75 acres) are shown in Fig. 1. The average infiltration rate on spreading areas

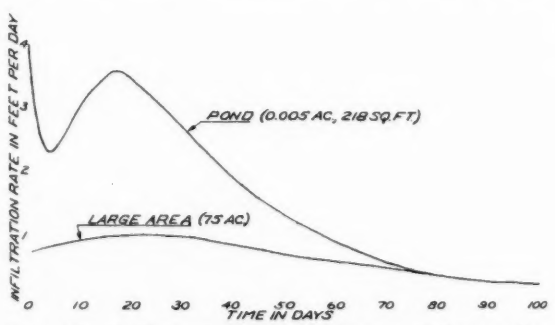

Fig. 1 Typical infiltration-rate curves of Exeter sandy loam or Hesperia sandy loam on an untreated, undisturbed pond and an untreated, disturbed large area

larger than 16 acres is about 0.5 ft per day for a spreading season. Local cooperators engaged in water spreading say that average infiltration rates of 1.5 ft per day over a spread-

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Paper presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at Stockton, Calif., January, 1954. This paper is based on studies by the Division of Irrigation Engineering and Water Conservation, Soil Conservation Service, U.S. Department of Agriculture. (The activities of the Division were transferred to the Soil and Water Conservation Branch of the Agricultural Research Service, USDA, January 1, 1954.)

The author—LEONARD SCHIFF—is research project leader, irrigation and drainage investigations, soil and water conservation branch (ARS), U.S. Department of Agriculture.

Acknowledgments: Grateful acknowledgment is made to Curtis E. Johnson who conducted investigations on soil conditioners with the author and made various suggestions and to Eldred S. Bliss for cooperative work on other soil treatments. The review by Dean C. Muckel led to helpful suggestions. Suggestions by Fred F. Horne are gratefully acknowledged. The facilities made available and the help of the Kern County Land Company and North Kern Water Storage District are appreciated. This work was also made possible by other cooperators under informal agreement, namely, the U.S. Bureau of Reclamation, the California Agricultural Experiment Station, and the California State Division of Water Resources. Appreciation is expressed to various chemical companies for the supply of materials as follows: Monsanto Chemical Co. — krilium; Crownite Corp. — pumice; Zellerbach Paper Co. and Braun Corp. — orzan; Stauffer Chemical Co. — flotal, and the California Spray-Chemical Corp. — orthorix spray and ortho algicide.

ing period would be satisfactory. Higher rates are desirable, however. Reasons for the lower infiltration rates on the large area appear to be: Removal of topsoil, breakdown of existing soil structure, compaction of soil, and the fact that water cannot flow laterally over the slowly permeable, subsurface soil layers as it can where a small surface area is wetted. Land leveling and soil manipulation by heavy equipment are responsible for the first three reasons. Since water from a small area of surface soil that reaches a less pervious horizon is free to move laterally over such a horizon, the infiltration rate approximately equals the potential infiltration rate. The percolation rate of the lower soil horizon has little effect. Water from a large surface area, however, is confined more or less to a vertical flow downward. Except at the periphery of the area, flow thus confined is limited by the percolation rate or rate of water movement downward through any existing less pervious horizon. On large areas, a major problem exists when there is continuity of flow between the surface and shallow, less pervious, subsurface horizons.

Objective

The major objective is to increase and sustain infiltration rates above those shown in Fig. 1 by some means, such as treating soil or water or both, and/or by using appropriate operational procedures. These procedures involve such considerations as amounts, depths, and locations of soil treatments, methods of manipulating the soil, methods of initially wetting or incubating the soil, duration of wetting and drying periods, size, shape, and spacing of spreading areas, and surface head. The development of higher infiltration rates for the disposal of industrial and sewage effluents may tend to reduce odors as well as decrease the size of spreading areas. Soil treatments are designed to increase the size of soil pores, and the stability and continuity of pores through the soil surface or through lower less pervious horizons or both. Things which tend to reduce or clog pore space, such as the dispersion, slaking and swelling of soil particles, leaching and deposition of material, biological and chemical activity, and compaction, must all be considered.

Summary and Conclusions

Various soil treatments and operational procedures to increase infiltration rates are available. Among them are: vegetative — cotton-gin trash and Bermuda grass; chemical — krilium, orzan, flotal; mechanical — injection shafts and injection ditches, and operational — depths and location of treatment, size and shape of spreading areas, arrangement of areas, length of incubation and drying periods, cultural operations, and surface head. Infiltration rates have been increased on small areas. Using proper treatments and operational procedures, it should be possible to achieve high potential infiltration rates on large areas. This improvement will not be economical or practical on large areas if the potential infiltration rate achieved is greater than the percolation rate. On large areas, unlike small areas, a much smaller proportion of the water moves laterally over less pervious, subsurface horizons.

It would seem that treatment of surface soil to make the potential infiltration rate higher than the percolation rate should be restricted to smaller areas. The potential infiltration rate can be achieved because the water can escape laterally and percolate downward beneath adjacent farmed areas. A good arrangement would appear to be long, relatively narrow spreading strips for maximum lateral flow. *By this method, it may be possible to spread about as much water by flooding a small treated portion of a large area as flooding the entire area even if the entire area is treated.* Adjacent areas may be used as alternate spreading strips rather than farmed areas. These alternate spreading strip-areas could be used in a rotational system, some strips flooded while others are being dried for recovery in infiltration rates.

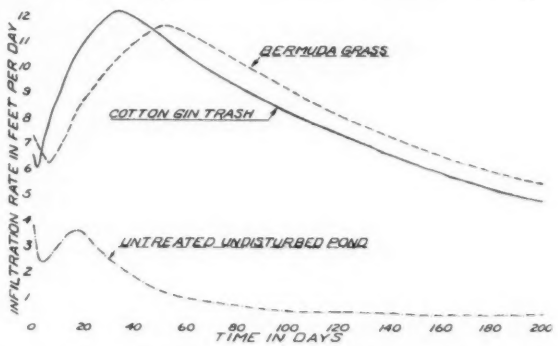

Fig. 2 Typical infiltration-rate curves of local soils on untreated, cotton-gin-trash treated, and Bermuda grass ponds

There is also a greater opportunity for gas to escape under alternate-area water spreading. The gases are produced by microorganisms in the soil as they break down organic matter. When large areas are flooded, particularly for a long period of time, some of this gas is trapped and retards the downward movement of water. Low infiltration rates over a long period of time is conducive to the development of anaerobic conditions and the production of gases that are not readily soluble.

Injection shafts and ditches, dug through less pervious, subsurface soil horizons, have increased infiltration rates, percolation rates, and lateral flow by making direct contact with aquifers and subjecting aquifers to greater hydraulic head. Clogging of the interface between the aquifer and shaft or ditch should be prevented as it reduces the rate of flow.

Previous Work

Early work in spreading water on coarse sands and gravels was concerned largely with building and maintaining diversions, dikes, revetments, and ditches, Mitchelson (1).* Methods of spreading water over the land and through shafts were discussed by Muckel (2). Christiansen and Magistad (3) explained the S-shaped infiltration-rate curves usually found in three phases: The initial decrease is due to swelling and dispersion, the following increase accompanies the removal of entrapped air, and the final decrease is due to the products of biological activity in the soil. The products of biological activity upon drying improve soil aggregation and increase infiltration rates, McCalla (4). By maintaining a sterile system, Allison (5) sustained peak permeability of soil in percolation tubes, thus substantiating the theory of biological sealing. Muckel (6) discussed results obtained with soil treatments of test ponds begun in 1936 by project cooperators. Bliss and Johnson (7) discussed laboratory work and later work on test ponds

*Numbers in parentheses refer to the appended bibliography.

by project cooperators. Outstanding increases in infiltration rates were reported with cotton-gin trash and Bermuda grass (Fig. 2). The beneficial effect of cotton-gin trash has now lasted for 6 years. The run shown for Bermuda grass was made 5 years after the grass was planted. At one time, this grass had survived a major dry period lasting 13 months. Cooperators have tried several other treatments, such as the use of gypsum, calcium chloride, detergents, removal of crusts, and removal of topsoil, all considerably less beneficial than cotton-gin trash and Bermuda grass.

Progress has also been reported on reclaiming and spreading sewage effluents. Water reclaimed from sewage is competitive in cost with water obtained from other sources according to the Board of Engineers of Los Angeles County (8). Stone and Garber (9) stated that infiltration rates of about 2 ft per day could be expected in spreading a final sewage effluent on a relatively coarse soil. The Sanitary Engineering Research Project of the University of California (10) concluded that a bacteriologically safe water can be produced from settled sewage or from final effluent, if the liquid passes through at least 4 ft of soil. It is reported that a final effluent can be expected to enter Hanford fine sandy loam at a rate of at least 0.5 acre-feet per acre per day.

Procedure

Field experiments are performed on Hesperia sandy loam near Wasco, Calif., and on Exeter sandy loam near Minter Field. Laboratory experiments are being conducted at Bakersfield on these same soils as well as on water and soil samples obtained from field experiments. Hesperia sandy loam is a recent to young alluvial soil showing little profile development. The upper subsoil layers are like the surface soil, although the materials show changes in texture due to stratification. The surface soil of Exeter sandy loam is a non-calcareous sandy loam containing subangular mineral particles. It contains sufficient colloidal material to bake hard on drying, but breaks into porous, irregularly shaped, angular clods that readily break down to a loose tilth. This 6 to 18-in layer is underlain by a non-calcareous layer of similarly to slightly heavier texture which may be more compact but in many places is loose. This layer rests on discontinuous hardpan at variable depths ranging generally from 36 to 48 in.

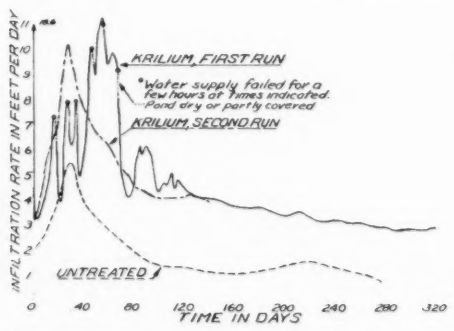

Fig. 3 Infiltration-rate curves of Hesperia sandy loam on pond 19 before and after treatment with krilium

Well water is used generally, and canal water occasionally, in small test ponds. Canal water is used on larger areas. Water supplied to ponds is regulated by float-controlled valves and measured by commercial-type water meters. Weirs are used to measure water moving into and out of larger areas. Water is supplied to test units at a rate equal to the rate at which water can pass through the surface of the soil into the soil mass at a given surface head.

Soil treatments and, in some instances, water treatments are being continued on infiltrometers 9 to 12 in in diameter; test ponds, 0.005 acre or 218 sq ft in size, and on checks or areas of ½ acre to several acres. The ponds are formed with wooden or metal borders that extend about 12 in below and 18 in above the surface. The checks are parts of spreading areas which are up to 100 acres or more in size. Infiltrometers and piezometers are being employed in the field to determine the soil-water movements and losses in hydraulic head. The Darcy and continuity equation are involved as saturated flow usually occurs under water spreading conditions.

SURFACE SOIL TREATMENTS

Cotton-gin Trash on Large Areas

Cooperators have incorporated 2 in of cotton-gin trash 6 in in depth of Exeter sandy loam and Hesperia sandy loam on several spreading checks. These checks, which are parts of large spreading areas, were formed by leveling land and building dikes. Checks treated with cotton-gin trash are now going through incubation or wetting and drying periods. Even when a porous surface condition is developed — probably after a few water spreading seasons — present low infiltration rates may not be appreciably increased due to any less pervious, subsurface horizons or the effect of soil manipulation. Volume-weight measurements indicated compaction has occurred to about 18 in of depth. Ripping some of the cotton-gin-trash checks to depths greater than 18 in increased infiltration rates from less than 0.5 ft per day to over 1.0 ft per day. Further increases in infiltration rate may be expected after complete decomposition of the cotton-gin trash.

Bermuda Grass on Large Areas

Bermuda grass was seeded on Hesperia sandy loam on several checks and is irrigated occasionally. Good volunteer growths of Bermuda grass have developed on some of the other checks. It will take time for the Bermuda grass to become well-established and for the detrimental effects of soil manipulation to be negated.

Krilium on a Small Area

Fig. 3 shows the high sustained infiltration rates of Hesperia sandy loam on pond 19 treated with krilium (CRD-186 — calcium salt of vinyl maleic acid). The lower curve, marked "untreated," in Fig. 3 is the best run prior to treatment with krilium. Dry soil was spaded to a depth of 6 in and raked to a depth of 3 in. Krilium was incorporated as a powder 0.1 percent by weight (about 6 lb for the .005 acre pond) in the surface 3 in of dry soil by raking vigorously. The soil was saturated, dried for a period of about 1 month, and the first test run was started. The maximum infiltration rate was 11 ft per day. This is about three times the normal infiltration rate of similar soil untreated at the surface. Infiltration rates remained high. When the test was completed after 320 days, the rate was 3 ft per day. Unlike organic matter and vegetative treatments, Krilium was effec-

tive on the first run. This is an important consideration in water spreading.

The 81-day drying period between the first and second runs was longer than necessary under the climatic conditions prevailing. Drying to about the permanent wilting point appears desirable. The second run is still in progress, the last date shown in Fig. 3 is December 1, 1953. As in the first run, a high sustained rate is maintained over a prolonged period. The peak was reached in less time on the second run, probably due to the fact that there were no interruptions in water supply such as occurred accidentally during the first run. Such interruptions result in air being drawn into the soil wherever the water level drops below the soil surface.

Soil samples brought into the laboratory from the krilium-treated soil showed definite improvement in aggregation, compared with samples taken from just below the krilium-treated depth. Observations indicate that the krilium tends to form a network of clay particles within which soil particles of various sizes are bound into aggregates. The treated soil probably prevents clogging that would normally occur on untreated soil at the surface and also provides a good transition of water into the untreated but similar soil below.

Pumice on a Small Area

Fig. 4 shows somewhat higher than normal infiltration rates of Hesperia sandy loam on pond 14 treated with pumice. Dry soil was spaded to a depth of 6 in and raked to a depth of 3 in. Pumice was incorporated 20 percent by volume in the surface 3 in of dry soil by raking. The maximum infiltration rate obtained with pumice was not greater than that obtained 4 years earlier after Dallis grass had been plowed under, but the somewhat higher sustained rate after the peak may be of importance. It was 1½ ft per day after 240 days and 1 ft after 320 days. The second run approaches normal infiltration rates for untreated ponds. This run is still in progress; the last date shown on Fig. 4 is December

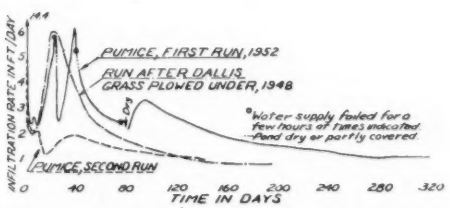
INFILTRATION RATE IN FT./DAY
PUMICE, FIRST RUN, 1952
RUN AFTER DALLIS GRASS PLOWED UNDER, 1948
*Water supply failed for a few hours at times indicated. Pond dry or partly covered.
PUMICE, SECOND RUN
0 40 80 120 160 200 240 280 320
TIME IN DAYS

Fig. 4 Infiltration-rate curves of Hesperia sandy loam on pond 14 before and after treatment with pumice

1, 1953. Presumably some clogging has occurred within the pore space during portions of the first and second runs. A dense volunteer growth of vegetation established between the first and second runs may also be a factor, the effect of which may change with time.

Pumice is a natural gray or white rock ejected by volcanoes and frothed by gases. The dead-end pores within each particle tend to prevent complete saturation and resist complete exhaustion of air. This air may prolong aerobic decomposition, at least during the early stages of wetting. The material may also prevent a certain amount of movement of soil particles.

Orzan on a Small Area

Fig. 5 shows higher than normal infiltration rates of Hesperia sandy loam on pond 23 treated with orzan (ammonium lignin sulfonate and wood sugars). Orzan was incorporated as a powder 0.5 percent by weight (about 25 lb for the 0.005-acre pond), in the surface 3 in of dry soil by raking vigorously. The soil was wet to a depth of a few inches and then dried. The crust that formed was broken gently with a rake, the soil lightly wet again, and then dried for 24 days. The first run on the orzan-treated soil was continued until the infiltration rate dropped below a practical

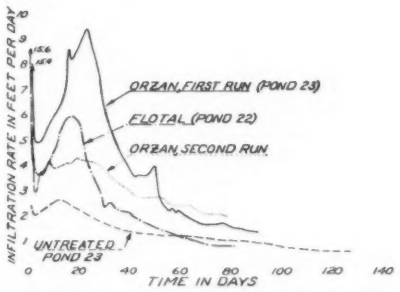
INFILTRATION RATE IN FEET PER DAY
ORZAN, FIRST RUN (POND 23)
FLOTAL (POND 22)
ORZAN, SECOND RUN
UNTREATED POND 23
0 20 40 60 80 100 120 140
TIME IN DAYS

Fig. 5 Infiltration-rate curves of Hesperia sandy loam on pond 23 before and after treatment with orzan and on pond 22 after treatment with flotal

limit. It took 3 months for this to occur. The decline in infiltration rates during the first run was attributed partially to the further decomposition of wood sugars in the orzan. A drying period was believed necessary for recovery in infiltration rates. Following drying and before starting the second run, it was noticed that a rather hard and dense surface crust had formed. It was thought desirable to try the second run, also shown in Fig. 5, without disturbing the soil in the event that good results might be obtained without further tillage. As anticipated, infiltration rates for the second run were not as high, probably due to the crust. The second run is still in progress; the last date shown on Fig. 5 is Dec. 1, 1953.

Flotal on a Small Area

Fig. 5 also shows infiltration rates of Hesperia sandy loam on pond 22 treated with flotal (ferric ammonium organic complex). Dry soil was spaded to a depth of 6 in and raked to a depth of 3 in. Flotal was incorporated as a powder 0.4 percent by weight (21.8 lb for the 0.005-acre pond) in the surface 3 in of dry soil by raking. The soil was then wet to a depth of a few inches and then dried. The soil was spaded, wet, and dried again before the test run was started. Flotal appeared to have little effect, when compared with the infiltration rates obtained on pond 22 previous to treatment. However, it has been reported that flotal is effective on soils of higher clay content than found locally.

SUBSURFACE SOIL TREATMENTS

Gravel-filled Injection Shafts Drilled Through Less Pervious Soil Horizons

Fig. 6 shows a high rate of water movement into a gravel-filled injection shaft. Injection shafts used in these experiments are 4 ft in diameter and 20 ft deep. Four of them are located within ponds on Exeter sandy loam at

Minter Field. Two ponds have one shaft each and one pond has two shafts. The shafts were drilled through less pervious material to contact aquifers and subject them to high hydraulic head. The maximum injection rate through shaft 37 was 1800 ft per day, or 0.52 acre-foot per day. This was computed by subtracting the rate at which water entered the soil around the shaft from the total rate at which water entered the pond. Approximately 26 acre-feet moved through shaft 37 for the 82-day period shown, about one-half of it in the first 30 days.

The decline in injection rate is due probably to the decrease in hydraulic gradient as water moves out in the aquifer and to some clogging at the interfaces of gravel and aquifers and deposition of soil in the shaft itself. Sand filters were used on the top of shafts to filter out materials carried by the water and to prevent the formation of algae on the gravel pack. Some soil did slough in around the sides of both shafts 37 and 36, however.

Shaft 37 is in contact with a greater area of aquifer material than shaft 36. The difference in rates in shafts 37 and 36 indicates the importance of appropriate soil-profile surveys to locate shafts and ditches where sufficient aquifer material will be contacted.

Injection Ditches Cut Through Less Pervious Soil Horizons

Deep, fairly long injection ditches are located on three spreading areas of different soils. The deeper of the two injection ditches at Minter Field is about 10 ft wide at the bottom, 1000 ft long, 10 ft deep with 3 to 1 side slopes, and contacts a fairly large area of aquifer material along the bottom and sides. Canal water was supplied to the deep

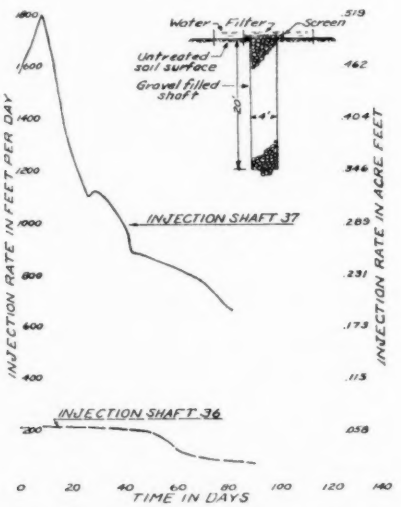

Fig. 6 Injection-rate curves of gravel-filled injection shafts 36 and 37 on Exeter sandy loam

ditch on Jan. 5, 1954. Water moved rapidly away from the inlet along the bottom of the ditch causing considerable movement of the loose, small particles of soil lying on the surface. On January 8 the ditch was full. Up to January 17, a total of 81.4 acre-feet had been supplied to the ditch. This is equivalent to a rate of 2½ acre-feet per acre per day based on a water surface area of 2.16 acres.

Injection rates probably are being retarded by the loose, small particles of soil which have undoubtedly moved into and clogged some of the large pores in the aquifer material. Anticipating such movement and soil dispersion due to other causes, krilium had been applied in bands on a small portion of the ditch. The effect of krilium on aggregating the soil will be determined after the run. After operation of an injection ditch, some scraping may be necessary to remove clogged surface soil, particularly if no steps have been taken to stabilize or aggregate the surface soil.

Ripping of Less Pervious Subsurface Soil Horizons

Ripping to depths of 42 in was tried recently on a few 2 or 3-acre checks on Exeter sandy loam, which is underlain by hardpan at shallow depths. Some benefits have been observed. Sometimes such treatment may require a companion treatment, such as the use of a soil conditioner, to aggregate small soil particles and restrict their clogging effect. Wherever ripped areas are underlain by less pervious soil horizons, little benefit will result.

OPERATIONAL PROCEDURES

Surface Head

Operational procedures that accompany soil treatments have been discussed. A special study has been made of the effect of surface head, Schiff (11). Infiltration rates increased directly proportional to total head in infiltrometers and ponds on untreated soils. The total head is composed of the depth of water on the soil surface or surface head and the length of saturated soil column. The surface head appears to be a large part of the total head on local untreated soils which have been partially clogged.

Water Treatments

Water treatments might ultimately become the most economical way to increase the rate at which water may enter the soil. Gypsum was tried on checks of about 3 acres with little success, but the severe negative effects of soil manipulation was still evident. Germicides are under consideration as well as chemicals that may reduce the clogging effects of calcium carbonates, iron compounds, and gypsum found in local hardpans.

A continuous water treatment that affects water properties or retards microbial activity may be helpful and desirable but may not be the ultimate goal. In treating water it would appear that a major goal is a single-shot water treatment that promotes soil aggregation and develops large pores in the soil for some time.

INFILTRATION RATES ON UNTREATED AND TREATED AREAS LARGER THAN PONDS

Development of High Potential Infiltration Rates

Soil treatment and proper operational procedures tend to prevent or offset the detrimental effects of soil manipulation. It may be possible, in some cases, to form the dikes from the outside or from cuts or ditches paralleling the dikes and thus avoid the detrimental effects of land leveling by heavy machinery. Ditches contacting aquifers under greater head may also be of additional benefit. It should be possible to handle and treat surface soils on large areas so that their potential infiltration rates approach the high infiltration rates of treated ponds.

Effect of Lateral Flow on Infiltration Rates

Water levels in piezometers were obtained on Hesperia sandy loam within and outside a cotton-gin-trash-treated test pond with high infiltration rates (11). Piezometric pressures were obtained within and above stratified soil horizons. A hydraulic gradient was found a few feet below the soil surface indicating laterial flow away from the pond above

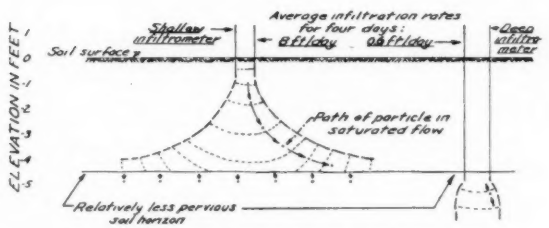

Fig. 7 Influence of lateral flow on infiltration rate

these stratified soil horizons. The build-up of water on the stratified soil horizons indicates that these horizons are less permeable. The effect of lateral flow by buffering or flooding the area around infiltrometers is illustrated in reference (11).

Fig. 7 shows that the infiltration rate of an infiltrometer driven down 9 in into Exeter sandy loam was about 8 ft per day, as compared with about 0.6 ft per day for a nearby infiltrometer driven down 58 in into the soil. The high sustained infiltration rate of the shallow infiltrometer is due largely to the lateral flow beneath it. Water, building up on the less pervious horizon, 54 in below, does not retard the rate of flow in the shallow infiltrometer. It is free to move away laterally and percolate downward over an area greater than the flooded area. The deep infiltrometer extends about 4 in from the 54-in to the 58-in soil level — into a less pervious horizon. Since lateral flow is prevented, the infiltration rate of the deep infiltrometer is controlled by the percolation rate of the less pervious subsurface horizon. The infiltration rate of the deep infiltrometer is slightly less than the maximum rate and about the same as the average rate of a large area of the same soil, Exeter sandy loam.

Practical Considerations of Treatments on Areas of Various Sizes

To what extent is it practical to raise potential infiltration rates on areas of various size by treatments and operational procedures? Some information on this question is provided by an exploratory experiment on untreated and krilium-treated, ½-acre, square-shaped, adjacent areas on Hesperia sandy loam. Dikes for both areas were constructed from the outside to prevent soil manipulation by heavy equipment. On one area, krilium, at a rate of 0.076 percent by weight (400 lb for the ½-acre), was worked into the top 3 in of soil with a rotary tiller. The untreated area was also rotary tilled 3 in deep for the sake of proper comparison. Water appeared in piezometers at a depth of about 9 ft below the surface of the ½-acre areas before the test runs were started, indicating lateral flow from adjacent flooded land. Borings in the ½-acre areas also showed some less pervious horizons at shallower depths.

Infiltration rates on these ½-acre areas are shown in Fig. 8. Some of the high lights are: Infiltration rates for the untreated ½-acre area are four or more times greater than on spreading checks constructed nearby by regular land leveling operations; soil structure on both the untreated and treated areas was quite good and was not destroyed by operational procedures; and infiltration rates on both ½-acre areas are about the same, except for the period July 6 to 8 when water was removed from adjacent areas, but application of water was continued on the ½-acre areas. When water was removed from adjacent areas the infiltration rate increased on the krilium-treated area. This was probably due to an increase in lateral flow and may be considered as the conversion of some of the potential infiltration rate to actual infiltration rate. There was no increase in infiltration rate on the untreated area. When water was again applied to adjacent areas on July 8, the infiltration rate on the krilium-treated area fell. Infiltration rates on the krilium-treated area just before the rise and just after the fall were alike. The increase in infiltration rate in response to a greater lateral flow opportunity indicated also a continuity of flow between the less pervious lower horizon and the soil surface.

The infiltration rate of the krilium-treated area averaged about 2 ft per day, even though it has a higher potential infiltration rate. Presumably the water movement in the profile is limited by a percolation rate of about 2 ft per day. It would appear that treatment of disturbed Hesperia silt loam on large areas to raise potential infiltration rates above 2 ft per day is unwarranted.

Capitalizing on Lateral Flow

A high potential infiltration rate may be achieved as a measured infiltration rate due partially to lateral flow which will occur under and away from long, relatively narrow strips of treated soil and possibly ditches. The infiltration rate measured on treated Hesperia sandy loam and treated Exeter sandy loam has been 10 ft per day and even higher. Data indicate an average percolation rate of about 2 ft per day and slightly less than 1 ft per day through less pervious, subsurface soil horizons on Hesperia sandy loam and Exeter

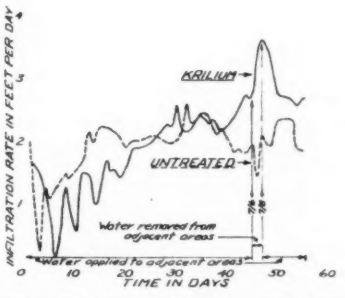

Fig. 8 Infiltration-rate curves of Hesperia sandy loam on untreated and krilium-treated one-half acre areas

sandy loam, respectively. At an infiltration-percolation rate ratio of 5 to 1 for Hesperia sandy loam, a unit area of soil at the surface would supply about 5 unit areas of less pervious soil immediately below and at right angles to a flooded, treated strip. The infiltration-percolation rate ratio would be 10 to 1 for a strip of Exeter sandy loam. Thus it would appear that for a specific large area, portions of land devoted to farming could be considerably larger than treated strips devoted to spreading. Treating the entire specific large area and spreading water over it would put little addi-

tional water underground. The areas between strips or ditches could be used as alternate spreading areas. Alternate spreading areas used in rotation may be helpful, particularly if microbial clogging takes place on the areas being flooded and reduces the infiltration rate below a reasonable amount. Recovery to initial infiltration rates usually follows adequate drying.

Effect of Gases on Infiltration Rates

The decline in infiltration rate on both untreated and treated areas has been attributed largely to the formation of gases, liquids, and solids. Following a drying period an untreated area shows little improvement in infiltration rate when compared with previous runs. This is due apparently to little secretion of beneficial liquids and solids by microorganisms. This is also consistent with the low organic matter content of untreated soils. Presumably the decline in rate during a run on an untreated area must be due largely to gases. The low infiltration rate on an untreated area is conducive to the development of anaerobic conditions. Anaerobic decomposition tends to produce gases which are not readily soluble. Further evidence of the apparent effect of gases may be seen in Fig. 4 on the first run on pumice. The pond went dry for a few days beginning on the 74th day as marked. Clogging gases probably escaped and air moved into the soil. When the water was again applied, the increase in infiltration rate was much higher than expected. This increase was due probably to the replacement of the clogging gases with air (more readily soluble) during the short dry period followed by the solution of air during the wetting period. Films of clogging material may also have been broken when the pond went dry. There may be a greater opportunity for gases to escape under alternate-area spreading, particularly rotational strip-area spreading where the soil will be alternately wet and dried again during the same spreading season.

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Tractor Hitches and Hydraulic Systems

(Continued from page 793)

implement designer and will have to be provided as a part of those implements requiring them, as follows:

1 *Provision for landing the implement.* On hillside or contour operation, it is often desired to maintain the width of cut of the implement. This is accomplished by means of a landing device which adjusts the implement sidewise with respect to the tractor.

2 *Provision for overload protective devices where required.* Tillage tools used in rocky or stumpy land and attached to a tractor of high horsepower require some protective device to prevent damage to the implement frame or soil-working elements. This is normally accomplished by means of shear pins or a type of spring release or trip mechanism.

3 *Independent depth-gaging means.* Some implements, due to their size or special operating characteristics, may not respond properly to the depth control means provided on the tractor. These tools may require independent gage wheels. The depth is varied by means of a lever or screw crank which can be reached from the tractor seat, or by use of a remote cylinder which can be operated from the tractor hydraulic system.

4 *Provision for allowing the implement to float laterally.* Implements such as a four-row lister are difficult to control laterally without the use of gage wheels, especially over uneven terrain. If the lister bottoms on the right side are operating at a greater depth than those on the left, the tractor becomes difficult if not impossible to steer. Such implements therefore require lateral movement or float between the hitch and the implement. Planters also require lateral float in order that the planting depth can be controlled over rolling ground conditions.

5 *Tractor longitudinal stability.* The design of a rear-mounted integral implement of a size which equals the drawbar capacity of the tractor often requires that the weight and length of the implement be held to a minimum, and that the implement be positioned as closely to the tractor as possible. With the implement in transport position, sufficient weight must be retained on the tractor front wheels so that the tractor with implement can be transported safely in fields and on roadways. If satisfactory tractor stability is not obtained by positioning the implement or by reduction of implement weight, then it will be necessary to resort to adding ballast to the tractor front end.

Conclusion

The different types of tractor hitches or integral implements on the market today have different operating characteristics on a common-type implement. A hitch that performs satisfactorily on a moldboard plow may not operate to any degree of satisfaction on a lister, cultivator or subsoiler. Each of the types of hitches covered in this paper performs better on some tools than on others. A type of a control that will satisfactorily operate a wide variety of tools is still desired.

An implement designer's viewpoint on tractor hitches and hydraulic systems is presented in the hope that tractors in the future will have common implement-to-hitch attaching points so that a tractor may be used with a number of different makes and sizes of integral implements.

Application of Anhydrous Ammonia Fertilizer

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The Development of Containers and Related Handling Equipment Required to Solve Application Problems

EQUIPMENT developments peculiar to the application of anhydrous ammonia have been concerned primarily with application metering devices, injection blades, and, more recently, specialized containers and accessory equipment. Although much also could be said about the many types of machines specifically designed for the direct injection of NH_3 into the soil, the process of direct application is similar enough mechanically to many heavy tillage operations that equipment for NH_3 service has been based on present tool carrier designs.

For the first several years after its introduction as a fertilizer in 1933, all commercial applications of NH_3 were made in irrigation water, and since 150-lb capacity cylinders used for industrial and refrigeration ammonia were suitable for agricultural service as well, the initial effort on equipment centered on the development of a satisfactory meter for dispensing in the field. When experimental work was begun in 1939 on the direct application of ammonia to the soil, methods of proper placement and effective sealing were the key elements to be worked out.

The most distinguishing feature of anhydrous ammonia as a fertilizer is its handling as a liquified compressed gas, which, among other things, eliminates the necessity for a pump or other external pressure source for metering in the field but does require pressure containers and accessory equipment for its handling. Its high nitrogen content (82 percent plus) reduces the total weight of product that must be handled, which in turn introduces the need for precise flow control to obtain uniform field applications. NH_3 pressures in agricultural service usually will range from 50 psig upward, in some cases well over 300 psig in hot weather areas. The liquid density changes appreciably with temperature, varying from 39.9 lb per ft^3 at 32 F to 36.4 lb per ft^3 at 100 F, and this high coefficient of expansion must be taken into account in the design of confined liquid systems. Ammonia is not corrosive to iron, steel, or aluminum, but in the presence of moisture will attack copper, silver, zinc, and their alloys.

The utility of NH_3 as a fertilizer comes from its solubility in water (up to 44 percent by weight) and its even greater affinity for the clay particles in soil. Low concentrations in the irrigation stream (110 ppm or less) will remain essentially constant the length of the run, and as the water penetrates into the ground the ammonia is taken up by the soil. However, solution in water is not a requirement for NH_3 application — anhydrous ammonia released a few inches beneath the ground surface is fixed in place, where it then is available to the crop.

If application rate alone were the criterion, progress to date could be considered very good indeed. There are machines now in the field with metering capacities up to 3200 lbs of NH_3 per hour and capable of fertilizing up to 200 acres per day. Of course, the major part of agricultural ammonia is applied on a more modest scale. For direct injection, a typical machine today would be a 30-35-hp row-crop tractor equipped with 3 to 10 injection blades, carrying 500 to 900 lb of NH_3, with a maximum metering capacity of 700 to 1,000 lb per hr, or a trailer-applicator of similar capacity.

Meters for Irrigation Applications

Since irrigation applications usually run from 12 to 24 hr and more, the first consideration in the design of flow meters for this service is reliability—the ability to maintain their rated flows for these time intervals with little or no service attention. NH_3 flow rates are relatively low, 10 to 150 lbs per hr being adequate for the majority of the applications. Some of the early meters look rather odd in retrospect and were as temperamental in their operation as they were cumbersome to handle. In our case, improvements were made along the lines of simplification until our present simple orifice meter evolved. This unit consists of a union assembly holding a calibrated precision orifice and a thermometer well upstream from the orifice for measuring the liquid temperature, which also is an indication of its pressure. In use, the required rate of NH_3 flow is calculated by multiplying the fertilizer application rate by the rate of irrigation, and the orifice size is chosen by reference to a flow chart. If the irrigation rate or the NH_3 temperature changes appreciably during the course of the application, the orifice size is changed accordingly.

A meter designed for easier adjustment of the flow rate has a pressure-reducing valve ahead of the orifice, and the flow rate can be changed either by means of the regulator setting or the orifice size. Although, as will be shown later, this system does not eliminate the effect of container pressure changes, it does have the advantage of requiring fewer orifice sizes to cover a given flow range.

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Minneapolis, Minn., June, 1954, on a program arranged by the Power and Machinery Division.

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Fig. 1 A typical "set" for nitrogation service. A serviceman turns on the NH_3 while the irrigator sets the water. The containers are ICC-3A-480 cylinders, each holding 150-lb anhydrous ammonia. The flow is controlled by a precision-drilled orifice in the special union fitting next to the operator's hand, and the NH_3 is carried into the standpipe through special ammonia and low-temperature-resistant hose

The obvious major improvement still to be placed on the market is a meter that will maintain a constant flow rate regardless of variations in container pressures and still retain present simplicity of operation. Units now under test are designed to meet these requirements.

A corollary problem in irrigation applications arises in hard-water areas in that NH_3 acts as a water-softening agent resulting in the precipitation of insoluble carbonates. In open-ditch irrigation, these precipitates are harmless but when deposited in pipe lines or syphon tubes will eventually plug them if uncontrolled. The precipitation is prevented by introducing a sequestering agent (sodium hexametaphosphate being one of several that is suitable) into the water ahead of the NH_3. Except for the hardest waters, 1 or 2 ppm concentration is sufficient. In use, the material is dissolved in water and the solution metered into the irrigation stream through calibrated capillary tubes from stainless steel "cans" equipped with a constant-head device to insure even flow.

On the whole, this arrangement has performed satisfactorily for the past 15 years or so, but the method has its drawbacks in that the concentrated solution is somewhat corrosive and rather messy to handle. Present developments are directed towards finding a slow-dissolving material that can be suspended directly in the irrigation stream and the rate of solution controlled by the wetted area.

Direct Injection Metering Systems

In addition to the requirements for irrigation meters, direct injection introduces the two additional factors of high flow rates and distribution of the metered flow to the injection blades. Injection flow rates normally run from 200 to 1,000 or more pounds per hour, and at the higher rates it is not at all unusual to have liquid line pressure drops from 2 to 5 lb between tank and meter. Fig. 2 illustrates the considerable effect these pressure drops have on the state of the ammonia entering the meter.* For instance, from an initial tank pressure of 50 psig, a 2-psi line drop will result in the vaporization of 0.313 percent of the liquid and the resultant mixture has a density of only 25.4 lb per ft^3 compared to 39.8 lbs per ft^3 for the liquid in the tank. Increasing the pressure drop to 5 psi reduces the density of the mixture still further, to 15.8 lbs per ft^3. Starting at 200 psig tank pressure, the corresponding mixture densities are 33.8 and 30.5 compared to 36.3 lbs per ft^3 in the tank at that pressure. Since either an orifice or a metering pump is essentially a volumetric control, and a uniform weight rate of NH_3 application is desired, these variations in density due to line pressure drop have, to say the least, a detrimental effect on the metering accuracy.

*Calculated from data in Bureau of Standards Circular No. 142 "Tables of Thermodynamic Properties of Ammonia" and assuming adiabatic expansion from saturated liquid. At the usual NH_3 flow rates and the relatively short lines, heat input from the surroundings is considered insignificant in comparison with the latent heat of the NH_3.

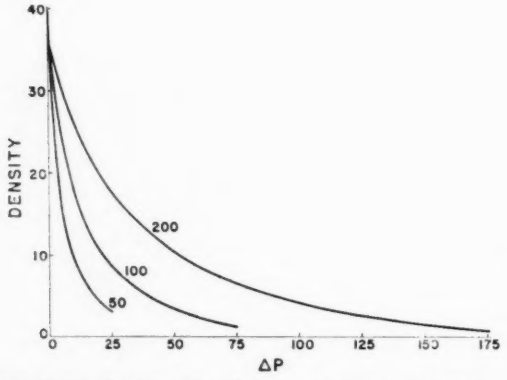

Fig. 2 Curves illustrating the effect on vapor-liquid mixture density resulting from adiabatic expansion from saturated liquid NH_3. The figures on the curves designate the initial liquid pressures before expansion

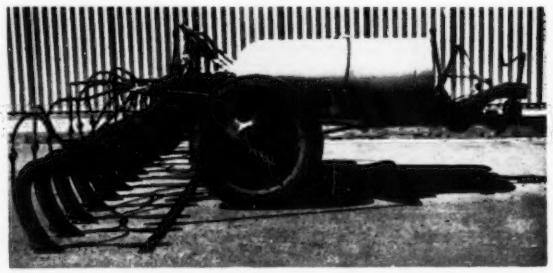

Fig. 3 A general-purpose NH_3 trailer-applicator used extensively for nitrojection service in northern California, featuring a low silhouette for orchard work and ground clearance sufficient for most row crops. The blades are cast steel, ¾ x 2½-in section, with replaceable chilled iron points and 2¼ in wide "fishtail" on the heel to open a channel for the NH_3 piped down the backs of the blades

The variables affecting NH_3 flow rate for injection are (1) rate of application, (2) width of tool bar, (3) applicator speed, and (4) NH_3 pressure. The meters used can be broadly classified into two types—the constant-flow type and the ground-driven metering pump. Due to their mechanical simplicity and favorable cost, the former are widely used even though the pump can be designed to compensate for both speed and NH_3 pressure variations.

The constant-flow types, with one exception, utilize orifices for flow control, usually in conjunction with a pressure regulator. The first type used commercially consisted of a separate metering orifice for each injection blade sized according to NH_3 temperature (or pressure), blade spacing, tractor speed, and application rate, but this has been superseded by more suitable types. A later development was a series of designs featuring a pressure-regulating valve ahead of the distributing manifold to hold a predetermined set pressure on the orifices. As in the similar model used for irrigation applications, the flow rate can be adjusted by means of the regulator setting as well as orifice size.

In order to eliminate the ammonia temperature variable, it is necessary to (1) hold a constant pressure differential across the orifice and (2) maintain constant fluid density. A regulator installed above the control orifice(s) introduces the same density variations caused by line pressure drop, so that tank-pressure changes will vary the flow rate. Therefore, we reversed this arrangement for our system and installed a differential regulating valve below the metering orifice, set to maintain a constant pressure differential across the orifice. Then, by minimizing line pressure drop between the container and orifice, the two conditions for constant flow are approached.

A more recent advance in simplification is a regulating-valve unit with a calibrated needle valve (variable orifice) for the primary control. A dial on the control knob is

marked in pounds per hour, which reduces the flow-setting effort to a turn of the dial.

Although one of the advantages of anhydrous ammonia as a fertilizer is that a pump is not required for delivery, there are situation where a ground-driven metering pump can be used to good advantage, primarily on steeply rolling ground where it is necessary to shift tractor gears. The generally used model is a single-cylinder variable-stroke pump, chain driven from a tractor or implement wheel, and with a maximum output of something over 1,000 lb per hr. Delivery is proportional to distance travelled rather than time.

An essential requirement for satisfactory operation of a metering pump is a heat exchanger of sufficient capacity to condense the vapor bubbles caused by unavoidable pressure drops in the tank-to-pump liquid line. A 2-lb line pressure drop from a tank pressure of 100 psig will cause sufficient vaporization to reduce the fluid density by over 17 percent, and the pump delivery would be reduced in proportion. In practice, the NH_3 from the pump discharge is expanded through a heat exchanger of sufficient capacity to cool and collapse the vapor bubbles in the incoming liquid.

This "chilling" principle also can be used to good advantage in improving the performance of orifice meters even though vapor formation prior to the orifice is partially compensated for by increased velocity of flow.

For specialized service, where manual control is desirable, a rotameter can be used to indicate the flow rate with a downstream needle valve control to adjust the flow. All steel rotameters with magnetic followers now are available and preferable, for safety reasons, over the glass-tube type. A heat exchanger also is necessary with this unit, since any vapor bubbles in the liquid will cause the rotameter float to bob erratically and prevent accurate reading of the float level.

One real question in regard to metering accuracy is a realistic determination of how good it has to be in relation to the other factors affecting crop production. Almost any order of mechanical precision can be built into the meters, and most of the units on the market today seem to be acceptable from the standpoint of flow control based on pounds applied per acre covered. With any fertilizer application machine distributing from a single hopper or tank, the operator can make a running check of the total poundage applied as he progresses through the field, but again, with any applicator, the operator can only assume that each boot or injection blade is handling an equal amount of material. Tests indicate that variations in lateral distribution are, in general, higher than metering variations, and, furthermore, relatively high differences between injection points are required to show up visually in crop response. This holds, of course, regardless of the form of nitrogen used. In any case, at the present time there is more room for improvement in distributor performance than in the flow controllers themselves.

Injection Blades

Probably every type of tillage tool and many other implements, such as planters and drills, have been used at one time or another for NH_3 injection. These include chisel cultivators, moldboard plows, narrow and wide-sweep blades, rod weeders, stubble mulchers, offset disks, wheatland plows, even spring-tooth harrows. The most widely used by far is the chisel cultivator type with blades spaced 12 to 24 in or more and running 6 to 8 in deep. A pipe or hose is attached to the back of the blade to carry the NH_3 to the bottom of the cut.

Since ammonia is readily absorbed by the clay particles in the soil, there is no problem in sealing the NH_3 in well-tilled ground. Average soils will absorb 0.1 lb NH_3 or more per cubic foot, and even at relatively heavy application rates the maximum discharge per blade will be in the order of 0.01 lb NH_3 per running foot of travel, so it does not have to penetrate very far laterally for complete absorption.

After trying a number of designs, the best sealing method we have developed so far is a so-called "fish-tail" or small "duck foot" 1½ to 3 in wide on the bottom of the blade with the NH_3 directed laterally into the channel thus formed. This proved more effective than some of the elaborate sealing devices previously used, though for unduly adverse conditions, such as wet clay or very trashy soils, chain drags or other channel closures are used to aid in sealing.

Blade designs, in general, are modeled after heavy-duty chisel cultivator blades, particularly for western soil conditions. General-purpose blade sections of ¾ × 2½ in to 1 × 3 in are used, although thinner blades (½ and ⅝ thick) often are used for side-dressing in row crops. Regions with lighter soils use the thinner sections almost exclusively; 1 × 1-in coil spring shanks seem to shed trash better than other types and also have proven the best answer to injection in stony soils.

(Continued on page 807)

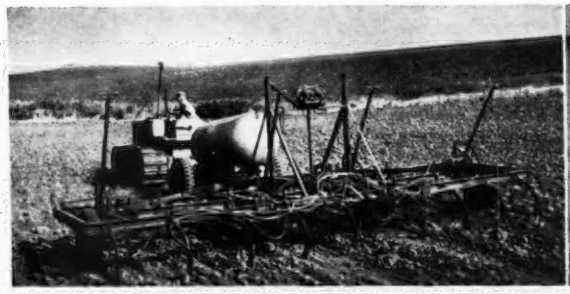

Fig. 4 A stubble-mulch plow adapted to NH_3 injection on wheat land in the Pacific Northwest. The blades are staggered to reduce trash build-up. A ground-driven metering pump is used here due to the many hills encountered in this area. The tank is built to ICC Specification 51 for 275 psig. W.P. and has a nominal capacity of 1730 lb of NH_3. • Fig. 5 In order to reduce over-all crop production costs, the NH_3 application sometimes is combined with another necessary tillage operation. One of the more successful of these is the moldboard plow application illustrated here. Anhydrous ammonia is particularly well adapted to this method. A length of hose from the distributor to each furrow places the NH_3 in the root zone of the crop and the dirt thrown over by the following share effectively seals the NH_3 in the ground

Head Loss in Irrigation-Line Quick Couplers

H. E. Gray, G. Levine, and M. Bogema
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Laboratory Study of Commercial Couplers to Determine Basic Values Essential to More Adequate Design

PORTABLE mains and laterals of sprinkler irrigation systems contain numerous fittings such as elbows, valves, tees, crosses, and quick couplers. These fittings cause head loss in addition to that due to pipe friction. It has become accepted practice in the design of irrigation systems to account for this additional loss by using the Scobey formula for friction loss in the pipe and applying a greater friction coefficient than the values obtained experimentally for straight pipe without the couplers.

The most commonly used value for this friction factor for aluminum pipe with fittings is 0.40. Thus Scobey's formula, when applied to the design of aluminum irrigation main lines with fittings, becomes

$$H_f = \frac{0.40\, L\, V^{1.9}}{1000\, D^{1.1}} \quad \ldots\ldots\ldots\ldots \quad [1]$$

where H_f = friction loss in feet
L = length of pipe in feet
V = mean velocity in feet per second (fps)
D = internal diameter in feet.

If all couplers and fittings were identical in design, one value could be used to cover all cases. However, many different types of couplers and fittings are commercially available, and no two types are identical. Hence, it is logical to expect the head loss from different types of couplers to vary.

Recently the authors completed a study of the head loss through several different types of commercially available quick couplers. The purpose of this study was to determine values which would serve as a basis for more adequate design. It was also felt that such a study might furnish information which would be helpful in reducing head loss in the future design of couplers. The results of this study are the subject of this paper.

Test Equipment and Procedure

The couplers used in these tests were stock models of standard 3-in size furnished by the manufacturers. All couplers were tapped for risers, and the riser holes were closed with standard plugs. The flow of water was obtained by an electrically driven centrifugal pump. Flow rates were measured by a calibrated orifice, and flow was controlled by a valve upstream from the orifice. Pressure taps for measuring head losses were located as shown in the schematic drawing of the general test layout in Fig. 1. The lengths of straight pipe upstream and downstream from the taps were sufficient to insure uniform flow conditions at the taps.

The four pressure taps were connected to a multiple-tube water manometer which permitted simultaneous reading of over-all loss (first to last tap), and normal pipe loss in 8-ft sections upstream and downstream of the coupler. These simultaneous readings for each flow rate permitted a direct computation of the loss due to the coupler in excess of normal pipe loss.

Each coupler was first tested in an aligned position, with the axes of the upstream pipe and the downstream pipe in a straight line; it was then tested in a misaligned position, with the axis of the upstream pipe at an angle with the axis of the downstream pipe, if construction of the coupler permitted. The amount of misalignment was measured by the offset angle between the two pipe axes. Following the misalignment test, the coupler was tested in an offset position if its construction permitted. In the offset position, the axes of the two pipes were parallel but not in line. Amount of offset was measured by the perpendicular distance between the two pipe axes.

In each position all couplers were tested at 20 different flow rates varying from approximately 50 to 150 gpm.

Description of Couplers Tested

The characteristics of the couplers tested are best described by the cross-section drawings in Fig. 2. Couplers A, B, C, and C-1 are classed as double-end couplers, that is, with a quick-coupling arrangement at both ends. Coupler C-1 is a modification of coupler C with an internal ring in the upstream end which holds the coupler on that end of the pipe more rigidly. With the exception of C-1, the double-end couplers were tested in three positions—aligned, misaligned, and offset. The internal ring in C-1 did not permit the coupler to be offset.

Couplers D, D-1, E, F, G, and H are single-end couplers with one end fixed rigidly to the pipe and the quick-coupling arrangement on the other end. Couplers D, D-1, and E utilize male gaskets, whereas the others use female gaskets. Coupler D-1 is in reality coupler D with a different type of gasket. This permitted a direct comparison of the relative effects of the two different gaskets in the same coupler. All single-end couplers, with the exception of D-1, were tested in the aligned and misaligned positions. D-1 was tested in the aligned position only.

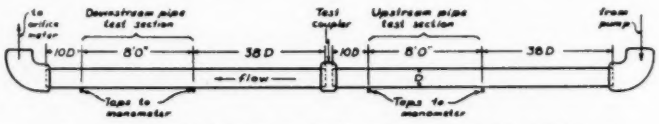


Fig. 1 Schematic diagram of the Cornell test setup for the determination head loss in irrigation quick couplers.

Couplers J and K are special single-end couplers with a portion of the coupler attached to each pipe and the quick-coupling arrangement within the coupler itself. These couplers were tested in the aligned and misaligned positions.

Paper prepared expressly for AGRICULTURAL ENGINEERING. This is the second of two articles on the subject of friction loss in aluminum irrigation mains and laterals. The first article, reporting results of a recent study on friction loss in aluminum pipe, appeared in the preceding issue of AGRICULTURAL ENGINEERING.

The authors—H. E. GRAY, G. LEVINE and M. BOGEMA—are, respectively, associate professor and assistant professor of agricultural engineering, and professor of hydraulics, Cornell University.

Couplers L and M are internal couplers which attach rigidly to the pipe. These couplers were tested in the aligned position only.

Test Results

Results of the tests of head loss due to each coupler, with the exception of L and M, were expressed both in terms of a resistance coefficient, K from the formula, $h_F = K(V^2/2g)$, and in terms of an equivalent length, representing that length of straight pipe that would give the same loss at the same rate of flow. A summary of these results is given in Table 1.

When consideration was given to the head loss-velocity relationship in these tests, the results showed that, with the exception of couplers L and M, the head loss due to each coupler in excess of normal pipe loss varied as the velocity squared, or closely approximated this value. Since the computed values of K for the 20 runs in each test showed only a small variation over the entire range of flows used, each value given in Table 1 is an average taken from the results of the 20 flow rates for each coupler in each position.

For each run of each coupler, the equivalent length was computed on the basis of loss due to the coupler in excess of normal pipe loss. Results showed an increase in the equivalent feet of pipe with increasing velocity of flow. This is to be expected as it has previously been shown that the

TABLE 1. SUMMARY OF TEST RESULTS OF HEAD LOSS THROUGH COUPLERS

Coupler	Position	Resistance coefficient, K (50 - 150 gpm)			Equivalent feet of pipe (100 - 150 gpm)		
		Aligned	Misaligned	Offset	Aligned	Misaligned	Offset
A	Aligned	0.18			2.6		
	Misaligned 12 deg		0.24			3.5	
	Offset 3/16 in*			0.18			2.6
B	Aligned	0.18			2.7		
	Misaligned 12 deg		0.25			3.8	
	Offset 1/2 in*			0.39			5.6
C	Aligned	0.21			3.1		
	Misaligned 12 deg		0.31			4.6	
	Offset 5/8 in*			0.47			6.9
C-1	Aligned	0.18			2.7		
	Misaligned 10.5 deg**		0.27			4.1	
D	Aligned	0.34			5.0		
	Misaligned 12 deg		0.36			5.3	
D-1	Aligned	0.43			6.3		
E	Aligned	0.31			4.7		
	Misaligned 12 deg		0.33			5.0	
F	Aligned	0.28			4.0		
	Misaligned 12 deg		0.35			5.3	
G	Aligned	0.16			2.5		
	Misaligned 12 deg		0.37			5.3	
H	Aligned	0.15			2.3		
	Misaligned 6 deg**		0.16			2.4	
J	Aligned	0.21			3.2		
	Misaligned 6 deg**		0.22			3.2	
K	Aligned	0.70			10.9		
	Misaligned 12 deg		0.84			12.5	
L	Aligned		See discussion of results				
M	Aligned		See discussion of results				

* Maximum offset possible. ** Maximum misalignment possible.

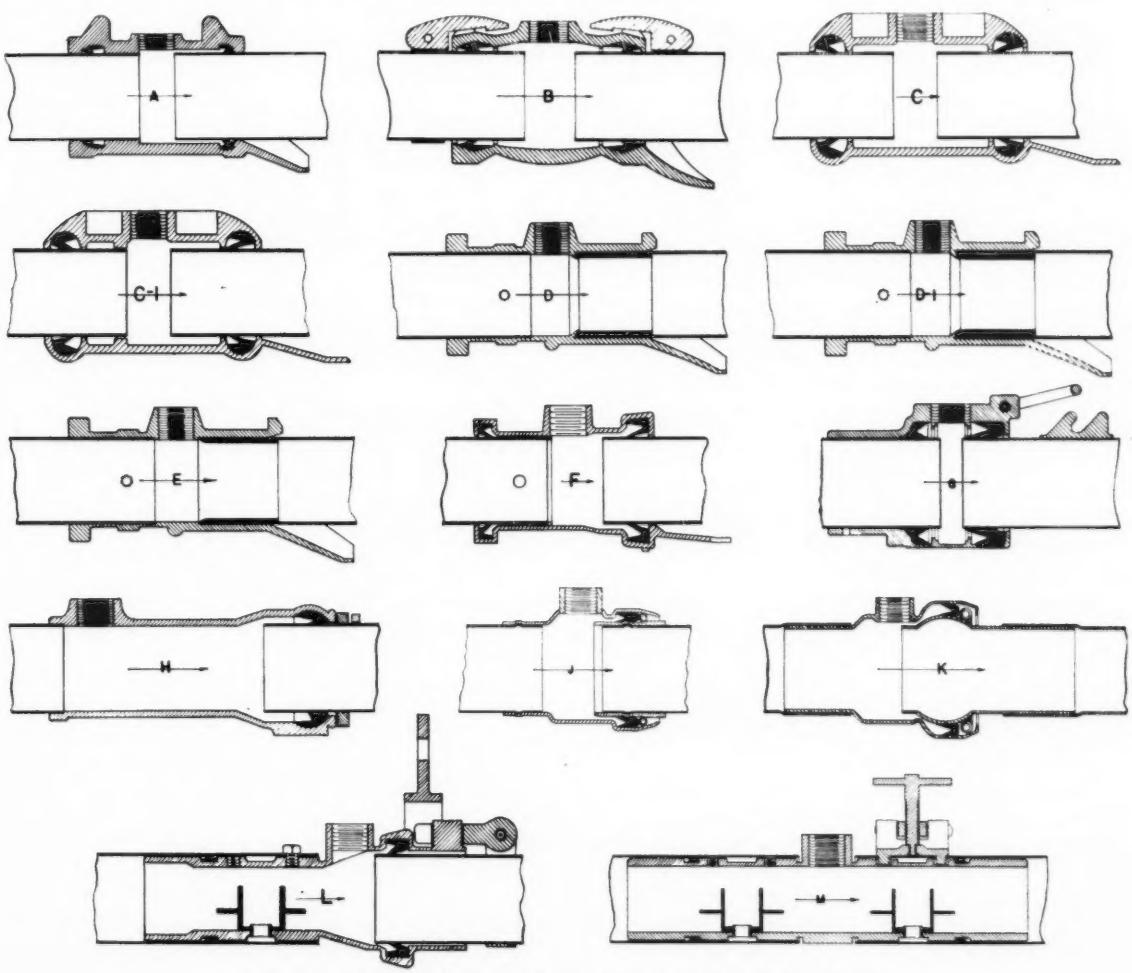


Fig. 2 Cross sections of irrigation-line quick couplers used in the Cornell tests

friction loss in aluminum pipe varies as the velocity to the 1.75 power,* whereas the loss due to the couplers varies as the velocity squared. Hence the value for equivalent length does not remain constant for varying flow rates. These variations will be greater for the lower flows and less for higher flows. In the data collected, variations for flow rates in excess of 100 gpm were not appreciable. Since, in irrigation practice, the range of flows is generally higher than 100 gpm for 3-in pipe, values shown in Table 1 were computed for the flow rates from 100 to 150 gpm.

Discussion of Results

In the discussion that follows, some comparisons are drawn between the internal construction of the couplers within a particular class of coupler and the effects of this construction on head loss due to the coupler. Comparisons are also made of the relative effects of the different positions of a given coupler.

Similar results were obtained from all of the general group of double-end couplers. The misaligned position of these couplers caused greater loss than the aligned position. Further increases in loss were noted through couplers B and C when they were offset. The latter increase was not noted for coupler A, in which the close fit of the coupler to the end of the upstream pipe considerably restricted the amount of offset that was possible. The modification of Coupler C, as shown by C-1, resulted in slightly reduced head loss, although the difference was not great. The internal ring in the upstream end of C-1 restricted the amount of misailgnment that was possible.

In testing the couplers with the male gaskets, the same gasket was used in both D and E. The difference then in the couplers is the shroud ring in the downstream end of D against which the male gasket butts to form the seal. A comparison of the results with D and E indicates that this shroud ring increased the head loss. A comparison between D and D-1, which are the same coupler with different gaskets, shows that the gasket in D-1, which further restricts flow because of a smaller internal diameter, resulted in a greater head loss.

If coupler E were compared to coupler F, the attachment to the end of the upstream end of the pipe is similar in both cases. The primary difference then lies in the fact that F uses a female gasket downstream, whereas E uses a male gasket. Although the difference was slight, the results would seem to favor the female gasket in the aligned position. However F caused a greater head loss in the misaligned position, probably due to the conditions of re-entry.

It would be difficult to compare coupler G to any of the other couplers on the basis of design. Head loss in the aligned position was low, but there was considerable increase in head loss when misaligned.

Head loss due to coupler H was low in both the aligned and the misaligned position, with no appreciable difference between the two. In the design of this coupler, there is no change in internal diameter from the pipe to the coupler at the upstream end. At the downstream end the enlargement is tapered prior to re-entry into the pipe. Moreover, this coupler restricts the amount of misalignment that is possible.

There was no appreciable difference between the performance of coupler J in the aligned and misaligned positions. Both ends of the coupler are pressed onto the outside of the pipe, and the major resistance is the re-entrance of the water to the pipe.

Coupler K produced greater head loss in both the aligned and misaligned positions than any of the other couplers tested, with the exception of L and M. The pipe is pressed onto the outside of the pipe on both ends, causing some restriction in the internal diameter. Moreover, the enlargement closely following re-entry on the downstream end apparently causes considerable turbulence with resulting head loss.

The high head losses through couplers L and M could not be measured on the 48-in water manometer through the entire range of flows up to 150 gpm. The maximum flow for which head loss could be measured for coupler L was 108 gpm; for coupler M the limit was 99 gpm. Nevertheless, 20 test runs were made of each coupler in the aligned position from the lower flow of approximately 50 gpm. up to the limit.

In terms of equivalent pipe, coupler L showed a loss of 94 ft at 108 gpm, increasing to 127 equivalent feet when the flow decreased to 53 gpm. At 99 gpm, coupler M showed a loss of 110 equivalent feet of pipe, increasing to 178 ft at 51 gpm.

These reactions could be attributed to the action of the internal rubber flaps that cover the self-draining holes. If these flaps remain upright or nearly so at the lower flows, the extra resistance could account for the higher equivalent loss. As the flow increases, further bending of the flaps could reduce the resistance sufficiently to result in lower equivalent loss.

The extremely high head loss in these couplers is due in part to the amount of internal restriction. Coupler M, with greater length of restriction, had the greater head loss of the two.

The test results indicated that the excess head loss for L and M was almost directly proportional to the velocity of flow.

The application of these test results to field conditions for design purposes would require considerable further study. Since the head loss varies according to the position, consideration would have to be given to the selection of design values for an individual coupler based on experience. It would be difficult, if not impossible, to predict how many couplers in a line would be aligned, how many would be misaligned and by how much, and how many would be offset in the case of the double-end couplers. If the maximum value were selected, overdesign would result. On the other hand, the minimum value would not give adequate design. Consequently some value between these two should be chosen.

The obvious design method would be to compute the friction loss in the pipe and then add the coupler loss as determined by the formula $h_F = K(V^2/2g)$, using the K values as determined for each individual coupler. This, however, would involve some complicated calculations, particularly when dealing with branching flow as in the case of lateral lines.

Much more suitable from a practical standpoint is the use of equivalent pipe. With the exception of couplers K, L and M, test results indicate that a value of from 4 to 5 would cover most conditions in the range of flows from 100 to 150 gpm. Then, assuming that couplers are spaced 20 ft apart, the couplers would have the effect of increasing the head loss over straight pipe of from 20 to 25 per cent.

The formula for friction loss* in extremely smooth pipe is

$$H_f = f \frac{LV^{1.75}}{1000\,D^{1.25}} \quad [2]$$

with a value of 0.30 for f for aluminum pipe. Thus the loss in pipe with couplers could be computed by the same formula using a value for f of between 0.36 and 0.375.

Design with couplers such as K, L, or M should be treated individually.

Summary and Conclusions

In the study discussed in this paper, head loss tests were run on twelve different commercially available couplers. In addition, tests were run on slight modifications of two of the couplers. Tests were made at flow rates in the range of from 50 to 150 gpm.

Results of the test were given in terms of equivalent feet of pipe and in terms of values for K in the formula $h_F = K(V^2/2g)$. A method for the practical application of these test results was suggested using equivalent feet of pipe. Results are based on the friction losses as previously determined by the authors for 3-in aluminum pipe.

Before wide application of these test results can be made to field use for design purposes, additional tests should be made of couplers of other sizes and of couplers with branching flow.

*Gray, H. E., G. Levine, and M. Bogema, Friction loss in aluminum pipe, AGRICULTURAL ENGINEERING, vol. 35, p. 715, October, 1954.

Application of Anhydrous Ammonia

(Continued from page 803)

An obvious method of reducing over-all crop production cost is to combine the NH_3 application with one of the normal tillage operations. This works best on such heavy-duty implements as chisel cultivators, moldboard plows, and the stubble mulch plows used in grain-producing areas.

Tanks and Accessories

The chief influences on NH_3 container and related equipment designs are the twin factors of safety and the economics of handling. In regard to the former, detailed requirements and recommendations are listed by a number of public agencies and trade associations, including the Interstate Commerce Commission, National Safety Council, American Standards Association, Compressed Gas Association, Manufacturing Chemists Association, Anhydrous Ammonia Institute, as well as many state and local regulatory bodies. Two categories of field containers are widely used, namely, portable tank containers with a usual capacity of 600 lb NH_3 or more and bottle-type cylinders of 150 lb capacity or less. For containers in interstate service, rules for their fabrication are listed in H. A. Campbell's "Freight Tariff No. 9" published by the Bureau of Explosives of the Association of American Railroads. For tanks, the basic requirements are welded steel "Code" construction (ASME or API-ASME) for 265 psig W. P., adequate protection for valves and fittings, hydrostatic pressure test, and provision for periodic inspection and retesting. Cylinders are the seamless steel ICC 3A-480 (and −480X) type rated at a 480 psig working pressure.

The benefits accruing from container design improvements have included a considerable reduction in the steel weight per pound of NH_3 carried and container capacities covering a wider range of field operational requirements.

For flexibility in handling and use, the 150-lb capacity ICC cylinders have given excellent service. They can be set out singly for small applications or in groups for larger jobs and are particularly well adapted to meet the space limitation for mounting on row-crop tractors, especially when rear-mounted heavy-duty tool bars are used. However, as in the case of many commodities, substantial operating savings can be realized by bulk handling in larger containers. Field sizes now range from ¼ to 1 ton capacity with capacities up to 3 tons used on occasion. Container weight savings up to 45 percent and more for tanks over cylinders, from nearly 1⅓ lb down to less than ¾ lb steel per pound of ammonia capacity, are obtained by taking advantage of the maximum welding efficiencies permitted by the Code when radiographic inspection and stress relief are used.

Since 1948, tank valves and fittings, liquid-level gages, relief valves, and ammonia hose for agricultural service, have become stock items of supply, reflecting the greatly increased demand for anhydrous ammonia handling equipment. The first consideration in volume production, and thus lower cost, on these items was industry-wide standardization of fitting sizes, flow capacities, and pressure ratings. Present indications are that all three are still on the increase. For instance, as the demand for faster tank filling becomes more insistent, 1-in liquid transfer hose undoubtedly will generally displace the ¾-in size now widely used. The same holds true for hose lines on direct injection meters, where speculation on 1200 to 1500-lb-per-hr capacity meters is now at about the same stage as 700 to 1,000-lb-per-hr units were just a few years ago.

Improvements in anhydrous ammonia application equipment and techniques are continuous. This review of developments to date has shown that the basic mechanical requirements for the application of NH_3 as a fertilizer have been successfully worked out.

The better application meters probably have reached a degree of precision consistent with other factors affecting crop production, although there is room for improvement in flow distribution, reliability, and simplicity of setup and operation.

Injection blades have been designed to effectively place and seal NH_3 directly in the soil, in many cases even under adverse conditions. In addition. NH_3 injection has been combined with other tillage operations to further reduce the cost of fertilization.

The development of containers and related handling equipment has progressed in direct proportion to the extent that operating requirements and standardization of components have been settled upon within the industry.

Movement of Water in Soils

M. B. Russell and A. Klute

THE movement of water through soil is a physical phenomenon of practical importance that has been investigated extensively by engineers, physicists, agronomists, and geologists. Although the practical applications may vary widely among such groups, the physical principles governing the transport of fluids provide a basis for understanding the several phenomena involved. The laws of motion and the principle of the conservation of mass may be considered as the basic foundations for the theory of fluid flow. The classical Stokes-Navier equation describing the movement of a fluid is an analytical expression of the relation between such motion and several forces that are involved. Application of this equation to the complex physical system such as that of water flowing through a soil is practically impossible, however, due to the complexity of the boundary conditions that are required in order to obtain solutions to the equation. A more useful relation describing the movement of the fluid is based on experimental observations of the relation between the velocity of flow and the driving force causing flow. Nearly a century ago, Darcy (10)* formulated the law which has come to be known as Darcy's law. For our purposes it may be written in the form

$$V = Ki \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

where V is the volume of water flowing through unit cross-sectional area normal to the line of flow per unit time, i is the hydraulic gradient, and K is the hydraulic conductivity. As so written, the hydraulic conductivity is a function of the properties of the fluid and of the porous medium. In an attempt to remove the properties of the fluid from the proportionality factor between the flow velocity and the driving force, Darcy's law may be rewritten as follows:

$$V = \frac{-k}{\eta} \rho g i = \frac{-k}{\eta} \nabla \Phi \quad . \quad . \quad . \quad . \quad . \quad [2]$$

in which the driving force is denoted by $-\nabla\Phi$, η is the viscosity of the fluid, and V has the same significance as in equation [1]. The proportionality constant k is the intrinsic permeability or just the permeability. The driving force, $-\nabla\Phi$, is the negative of the gradient of the soil moisture potential Φ. This potential is based on a unit volume of fluid. The similarity of Darcy's law to Ohm's law, Fourier's law, and Fick's law has been pointed out many times. Recognition of this parallelism that exists between such transport phenomena has proved to be a stimulating factor in the development of models and analogues for study of certain problems of fluid flow.

The equation of continuity, which expresses the concept of conservation, may be written as

$$\frac{\partial \theta}{\partial t} = -\nabla (\rho v) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [3]$$

where ρv is the mass flux, ρ is the fluid density, and θ is the moisture content on a volume basis. By combining equation [2] with equation [3], it is possible to derive a general flow equation which may be written as

$$\frac{\partial \theta}{\partial t} = -\nabla \left(\frac{k}{\eta} \rho \nabla \Phi \right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [4]$$

This is the general flow equation and applies to saturated and unsaturated media. In the case of saturated media, the rate of change of moisture content with time is zero, and if one assumes that the permeability is a constant, the flow equation becomes

$$\nabla^2 \Phi = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [5]$$

which is Laplace's equation. Solutions of this equation are possible under certain conditions and considerable effort has been expended in obtaining them (17, 18). These solutions are analytical predictions of flow nets, and the distribution of potentials in the saturated porous media under stated boundary conditions. Generally it is assumed that the medium is homogeneous and isotropic with regard to its permeability.

Since the application of any of the forms of the flow equation involves knowledge of the transmitting characteristics of the medium, much attention has been directed to the determination of permeability (3, 4, 11, 25, 30). Laboratory measurements of the ratio of the rate of flow through soil cores to the potential gradient across the core are extensively used to determine the permeability. Since field soils are probably not often isotropic, and because it is necessary to obtain the sample in its natural structural form, the application of laboratory determinations of hydraulic conductivity or permeability to field problems leaves much to be desired. Certain of the difficulties involved in laboratory methods may be overcome by the use of field methods of measuring permeability (3, 4, 12, 18, 22, 25). The use of drawdown characteristics, and the piezometer, auger hole, and tube methods described by Reeve and Kirkham (25) allow one to determine the permeability of the soil in the field below a water table. However, uncertainties arise in such measurements due to the difficulties attendant with the accurate description of the geometry of the test system. It would be desirable to have available a method of measuring permeability in the field which would not require the presence of a natural water table. To the knowledge of the authors no such method has been developed.

Many investigators have studied the possibility of calculating the permeability of granular porous materials from other characteristics of such materials. Such parameters as particle size, porosity, specific surface, and pore size distribution have been used. If these parameters are measured on samples of disturbed structure, serious errors arise due to the fact that the naturally occurring structural arrangement of particles in the sample has been ignored. This type of error is, of course, less serious on homogeneous sands and gravels. When the physical parameters measured are those of undisturbed cores, the magnitude of the determination and sampling errors lead to calculated permeabilities no bet-

Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1953, on a program arranged by the Soil and Water Division.

The authors—M. B. RUSSELL and A. KLUTE—are, respectively, head, department of agronomy, and assistant professor of agronomy, University of Illinois.

*Numbers in parentheses refer to the appended bibliography.

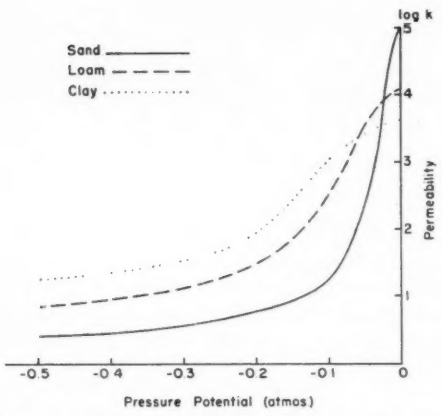
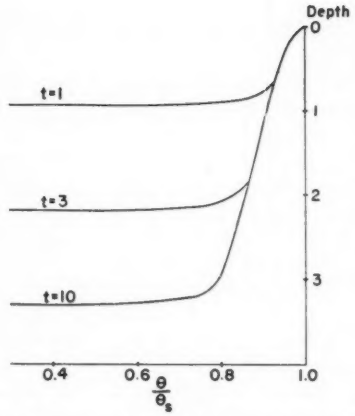


Fig. 1 *(Left)* Generalized curves showing the relation between permeability and pressure potential of soils of different texture • Fig. 2 *(Right)* Generalized distribution of moisture content as a function of depth during infiltration into dry soil



ter than those obtainable by direct measurement. When extended to the estimation of the permeability of unsaturated soils, however, it appears that deductions based on a statistical treatment of the pore-size distribution curve as proposed by Childs and George (5) have advantages over the direct measurement of unsaturated permeability. The methods for the determination of the latter are slow and involve considerable experimental difficulty. The pore-size distribution curve may be obtained from moisture desorption data, and this curve is obtainable without unreasonable difficulty.

A great lack of uniformity in nomenclature exists relative to the coefficient of permeability. Most of the differences can be identified with the manner in which the viscosity of the fluid is included in the working equation, Darcy's law, and the physical quantities used to describe the flux and the driving force. The ratio of the fluid flux through a layer of soil to the hydraulic gradient across the sample, herein called the hydraulic conductivity, is affected by the properties of the fluid and the soil.

A number of workers are of the opinion that the parameter called the permeability of a porous medium should be a property of the medium only, and not a property of both the fluid and the medium (15, 16, 26). For this reason Darcy's law is written as shown in equation [2]. Hubert (15, 16) and others have shown that the parameter k, the permeability, is a property of the medium and has the dimensions of a length squared. If there were no interaction between the fluid and the medium, e.g., swelling, the permeability could be determined with any fluid and the same value of the permeability would be found.

Although most of the problems of water movement in soils encountered by engineers involve movement through soils that are saturated, the phenomenon of moisture transport through unsaturated soils is of great importance in relation to plant growth. The introduction of the concept of soil-moisture potential by Buckingham in 1907 (2) and the pioneering work of Gardner (13, 14) and Richards (27) in the physical interpretation of this potential and the development of methods of measurement have led to a clearer understanding of water flow in unsaturated soils. It is now reasonably well established that, at any given degree of saturation and at flow rates low enough for laminar flow to obtain, Darcy's law may be applied to unsaturated soils (6). However, the coefficient of permeability is no longer a constant independent of the soil-moisture potential, but is highly dependent upon the degree of saturation of the soil and on the soil moisture potential. It has been suggested (7, 14, 27) that Darcy's law should be modified to apply to unsaturated soils by introducing a functional relationship between the permeability and the moisture content of the soil-moisture potential. If the moisture potential is considered as the sum of the gravitational and pressure potentials, it can be shown that the permeability should depend upon the pressure potential component of the total soil moisture potential. Thus we write Darcy's law for unsaturated soils as:

$$V = -\frac{k(p)}{\eta}\nabla\Phi \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [6]$$

in which the notation $k(p)$ implies that the permeability is to be considered as a function of the soil-moisture-pressure potential. The nature of the function $k(p)$ has been established experimentally on a limited number of soils (8, 28). A generalized summary of the type of results that may be found is shown in Fig. 1. The curves in this figure emphasize the tremendous reduction in water transmitting ability that results when soils become increasingly unsaturated. Thus the change from 0 to —0.15 atmospheres in the pressure potential in a sandy soil results in a relative reduction in permeability to 0.0001 of the value at saturation. Fig. 1 also shows that a reversal occurs in the relative permeabilities of soils of different textures when they are compared at complete and partial saturation, respectively. For example, at saturation the sand has the highest permeability, with the clay lowest. At a pressure potential of —0.15 atmospheres the opposite is true.

If one attempts to obtain solutions to the general flow equation in cases of unsaturated media, it is soon found that the introduction of a functional relationship between permeability and moisture content or pressure potential makes it difficult if not impossible to obtain an exact analytical solution. Solutions for the flow equation have been obtained for steady state conditions in which $k(p)$ functions have been used (7, 27). Under steady state conditions the flow equation becomes

$$0 = \nabla\left(\frac{k(p)}{\eta}\nabla\Phi\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [7]$$

However, many of the problems in unsaturated flow of water in soils are not problems of steady state, but are transient situations in which the moisture content of the medium is changing with time. Attempts have been made to treat these transient cases of flow, such as infiltration of

water into a soil. Kirkham and Feng (19) have applied diffusion theory to such a problem and found poor agreement between predicted and experimental results. This is attributed to the fact that the theory used by these authors did not consider the variation of the permeability with moisture content. From their theory they were unable to predict the wetting front that exists whenever water moves into an initially dry soil. Klute (20, 21) has shown that solutions of the general-flow equation may be obtained for horizontal flow by means of a numerical iteration process. Results from such calculations have indicated that a wetting front is predicted if the variation of the permeability with moisture content is considered.

Bodman and Colman (1, 9) among others (29, 23) have studied the problem of infiltration of water into initially dry soil. Their results are diagrammed in Fig. 2 in which the degree of saturation of the soil is plotted against the depth of the column. The wetting front moves downward into the soil with continually decreasing velocity. Behind the wetting front there is a zone through which water is being transmitted to the front. In this transmission zone, the soil is not saturated except for a rather shallow layer near the surface. Since the large voids are the first to be emptied in the process of desaturation, it follows that such openings would be free of water even in the wetted and transmitting zone. These results emphasize the fact that large cracks, root channels, and worm holes will be of no value in downward movement of water during infiltration unless they open directly into the free water on the soil surface.

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Correction

THE authors have called attention to two additional corrections in the paper entitled "Hot Weather Shelters for Livestock" by G. L. Nelson, G. W. A. Mahoney, E. R. Berousek, and Franklin Graybill, pages 638-643, 645 (see also corrections on page 674), published in AGRICULTURAL ENGINEERING for September, 1954, as follows:

As corrected the equation at the end of the second column on page 638 should read

$$t_s = \frac{a_D I_D + a_D I_D + \epsilon_L (R_S - R_L)}{f_{co}} + t_o$$

As corrected the definition of the term b in the last two lines at the end of the first column on page 640 should read

b = absorptivity of specimen for solar irradiation, dimensionless.

Graduates and Graduate Ratios

THE key to success in accurately predicting the size of engineering graduating classes, says the *Engineering and Scientific Manpower Newsletter* for October 15, 1954, is the determination of an accurate graduation ratio to be applied to enrollment. The Compton Committee in 1946 used a graduation ratio of 54 percent of entering freshmen four years earlier, which was the average for the years 1935 to 1939. A re-examination of the Compton Committee report in the fall of 1946 led to the adoption of a graduation ratio of 49 percent which was used in predictions of engineering graduates made in the spring of 1950. These predictions turned out to be somewhat low because there were more entering freshmen than had been anticipated and because the actual graduation ratio was higher than 49 percent.

Using the ratio of 57 percent and applying it to students in school during the academic year 1953-54, engineering graduations for the next three years are estimated as follows:

1954-55	23,000
1955-56	30,000
1956-57	34,000

An Agronomist Looks at Grass Silage

Rodney A. Briggs

A Consideration of the Various Factors Essential to Success in Producing a High-Quality Product

OUR nation's grasslands are becoming increasingly important each year. Many farmers are learning to use and depend upon grasslands in the form of high-quality forages to reduce the cost of producing milk or meat. Grassland farming with its emphasis on improved productive grasses and legumes is a comparatively recent development which can be directly attributed to the following four basic achievements of research both public and private:

1 Increased knowledge of the potential value of grasslands
2 The development of improved and productive varieties of grasses and legumes
3 The assurance of an adequate supply of high-quality seed at reasonable prices
4 The development of machinery and structures to insure the production, harvesting, and adequate storage of the crop.

Without these four basic developments we would not have a grassland program today. What then is a grassland program? It is simply a farming operation which emphasizes the production of grasses and legumes either alone or in combination with other crops. It is the ability of grasses and legumes to supply the feed requirements of livestock in the form of pasture, grass silage, or hay as well as improving the soil through erosion control, root penetration, and addition of organic matter.

The modern farmer is striving to develop a refined forage program on his farm which stresses the flexibility of grassland so that his seedings can be used for pasture, grass silage, hay, or soil improvement.

There are two major problems in the development of a sound grassland program. The first is in successful establishment of grasslands, and the second, after establishment, is realizing through harvesting and storage procedures the potential value of the crop. Grass silage is made in an attempt to retain the value of our common forage crops.

The potential value of our forage crops is high. It has been shown that equal amounts of TDN (total digestible nutrients) can be found in 80 bu of corn and a 3½-ton yield of alfalfa. However, under conventional methods of pasturing and making hay we lose much of the value of the alfalfa while having a complete harvest of the corn. Research has indicated inherent losses of pasturing due to tramping, manure contamination, animals lying down, and failure to graze overmature plant growth, at from 20 to 40 percent of the total value. Losses in conventionally made hay, without a rain falling on the cut crop, can range from 20 to 60 percent due to leaf shattering and bleaching. One method of handling and preserving the forage crop to insure against these losses in quality has been in the making of grass silage. This is true, however, only when we can make a high-quality product.

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Minneapolis, Minn., June, 1954.

The author—RODNEY A. BRIGGS—is extension agronomist, Institute of Agriculture, University of Minnesota.

What then is required to insure a high-quality grass silage at all times? First, possibly, we should understand the processes involved in grass silage and then develop the requirements.

Generally we could consider that silage is a fermented material. Fermentation is brought about by the action of bacteria, in the absence of air, on sugars, mainly saccharose and lactose, contained within the plant or added in the form of a carbohydrate preservative. The development of sufficient acid by fermentation to inhibit further bacterial action gives us the finished product.

Legumes, unlike corn, are low in sugars and high in protein. This lack of fermentable sugars favor an improper fermentation and the desirable acid formation is stopped before an acidity sufficiently high to inhibit further bacterial action has been reached and butyric acid is formed and putrefaction may take place.

This procedure of bacterial fermentation is altered in the case of the addition of mineral acids or sulfur dioxide or sodium metabisulfite. In the case of the former a sufficiently high acidity is rapidly reached to inhibit most of the fermentation, while with SO_2 or sodium metabisulfite, in addition to higher acidity due to acid formation, depletes the oxygen supply and causes more rapid death to the plant cells in the green material.

In general, we can handle green material from the field in two different ways as direct cut (fresh green material) or partially dried (wilted). Because of basic differences between these two types of silages, I shall consider them separately.

Direct, Cut Fresh Material

Our immature grasses and legumes are low in carbohydrates needed to effectively promote favorable bacterial action in the grass-silage process. Therefore, under conditions of high-moisture, direct-cut green material, a preservative is needed to direct the biological processes in the right direction. There are two types of preservatives on the market today which can be used: *(a)* sugars or other fermentable carbohydrates such as molasses or ground grains that aid fermentation, and *(b)* chemicals such as sulfur dioxide, sodium metabisulfite or mineral acids which inhibit fermentation.

Wilted Grass

Two different types of silage can be produced when using grass wilted in the field. These types could be classified as cold pack and warm silages.

The basic difference between these two types depends on the regulation of oxygen. In cold silage the wilted grass is chopped and is quickly put into silo and packed extremely well and covered to exclude oxygen. European workers indicate that this type of wilted silage has some definite drawbacks; if dry matter content is too low (below 35 percent), there can be a build-up of putrefactive fermentation, and if dry matter content is too high (above 50 percent), it is next to impossible to pack sufficiently well to exclude air.

Structures that can effectively regulate the oxygen supply

can make a good cold silage. Structures such as the glass-lined silos found on the market today show great promise. It is probably desirable, however, with very high moisture material, to use a preservative even in such structures.

If wilted silage is very gradually packed in loose layers and stacks, the temperature will rise. If the temperature rises rapidly, all bacterial action is stopped. This is a difficult procedure to insure even temperature rise throughout the green material. Losses of feed value are high, much of the energy is lost as heat, and there is a decrease in the digestibility of protein as well as high losses of protein.

Wilting silages to a 60 to 70 percent moisture level is a prerequisite for successfully making good wilted silage. Various authors have reported that the biologically active surface is not within the plant material, but at the surface. By controlling moisture content there is sufficient concentration of carbohydrates to insure proper fermentation.

As our productive improved grasses and legumes approach maturity, their dry-matter content increases. When cut at the proper stage of growth, our legumes are generally within a 70 to 80 percent moisture range, while the grasses are between 65 and 75 percent moisture. Many farmers take advantage of this loss of moisture by growing mixtures of legumes and grasses and cutting at early bloom stage or slightly later. When this is done little wilting is required as the standing crop has a moisture level desirable for making grass silage. It is important, however, that no outside moisture such as rain or dew is left on the plant as that can add to a higher than desirable moisture content.

Most wilted silages that I have observed have been a combination of these two silage types with an in-between silage produced. There is not sufficient heat rise to inhibit bacterial action and oxygen is not completely excluded to form a cold pack. Hence the potential loss of feed value may be great.

What then are the prerequisites or requirements in making a high-quality silage? The requirements include a complex of factors of length of cut, moisture control, proper fermentation or the inhibiting of fermentation, packing, and the exclusion of oxygen.

An important factor in insuring a high-quality silage from direct-cut, high-moisture material is the control of proper fermentation. In wilted material the control of moisture content has been advanced by many as the most important factor.

Packing and the exclusion of air in silage during the silage-making period is possibly the most important over-all procedure in insuring a high-quality product.

The bacterial activity of silage takes place only under anaerobic conditions, and if improperly packed, excessive heating, drying, molding, and rotting are the results along with an improper fermentation. Directly related to packing is the type of storage, length of cut, and moisture control.

We must consider three basic types of storage units—the upright, horizontal, and temporary—and the role each has on quality of silage. Conventional upright concrete, concrete stave, tile, or wood silos do permit proper packing, if a column of green material, sufficiently high, chopped short enough, and with moisture content high enough is used. The pressures developed due to weight of silage have been well defined and extra packing is only required in the upper portion of these structures. In insuring good packing of even upright silos, however, the length of cut and the moisture content create a distinct problem. High-moisture material may have a ½ to ¾-in cut. For wilted material a cut as fine as the equipment will allow is desirable. A theoretical ¼-in is best for good packing.

There has been some question of the value of a very short chop. A short chop is needed so that the green material can be moved in an air stream, will occupy less space (hence can be packed to exclude air), can be self-fed, can be moved and chopped out if frozen, and aid in fermentation. If we agree with the theory that fermentation takes place on the outside of plant material and not within the plant, machinery that will effectively increase the exposed surfaces will then insure proper fermentation. It has been reported that a stem crusher or cracker does aid in the fermentation of wilted silage.

In horizontal or temporary silos where we do not have a column of green material to aid in packing, precautions must be taken to insure more complete packing. Chopped green material that is put into these storage units should be higher in moisture than if put in uprights. Extra packing by wheeled tractors, if possible, is desirable in bunkers, trenches, and in stacks.

In northern areas of the United States freezing has created a major problem in upright silos. There is a great potential in the horizontal-type structure because of two features, no freezing and self-feeding.

Long-grass silage depends on high-moisture for proper packing. It should not be wilted.

It can readily be seen that in making grass silage many complex factors are involved. All is not known about the exact procedures necessary to always insure a high-quality product.

The farmer in the development of his forage programs demands machinery which will efficiently do a specific job of assuring the maximum production of feed from any given area from his farm.

What considerations must then be considered in the future development of grass silage?

We must aim at rapid efficient harvesting methods. The most promising is in direct cutting. It is felt that direct cutting with the use of preservatives is a desirable goal. Combinations of machinery effectively lowering the amount of machinery, time, and labor involved in making grass silage should be further investigated. The buck rake on some farms with limited forage acres can be the most efficient.

We should develop plans for low-cost, above-ground horizontal silos constructed of permanent or semipermanent materials so that they can be loaded easily, packed well, and easily fed from.

We should encourage structures suitable for self-feeding, thus reducing labor requirements of livestock management.

We must develop methods of sealing the exposed surfaces of all types of storage structures to prevent excessive drying and outside spoilage.

We must develop methods of efficiently applying preservatives to dried cut green material.

At present many farmers fail to realize the losses involved in their farming programs. Many, however, that do realize the value lost, feel that this loss is justified, and until such time that every acre is required for maximum feed production will continue to have high losses.

NEWS SECTION

Chicago Section Elects Ken Snyder

KENNETH W. SNYDER, of Aubrey, Finlay, Marley & Hodgson, Inc., Chicago advertising agency, was elected new chairman of the Chicago Section of the American Society of Agricultural Engineers at the Section meeting on October 18. He succeeds Lee H. Ford of the International Harvester Co.

The Section also elected three new vice-chairmen: Gerald A. Karstens, engineering director of the publication, *Feed Age;* E. B. Scott, division manager of agricultural sales, Public Service Co. of Northern Illinois, and Edwin G. Dueringer, director of agricultural research, A. O. Smith Corp., Milwaukee. Re-elected secretary of the Section is Erwin R. Johnson, manager of the International Harvester Co.'s experimental farm at Hinsdale. The new nominating committee consists of W. E. McCoy, W. H. Johnson, and D. E. Cash.

The program for the Section meeting on October 18 featured the subject of placement and handling of commercial fertilizers. A. L. Lange, professor of agronomy, University of Illinois, discussed the subject from the standpoint of solid fertilizers; Howard Lathope, agronomist of the Allied Chemical & Dye Corp., from the standpoint of liquid fertilizers, and Charles Wood, Olin Mathison Chemical Co., from the standpoint of anhydrous ammonia.

The Chicago Section will again serve as host to the ASAE Winter Meeting to be held at the Edgewater Beach Hotel in Chicago, December 6, 7, and 8.

Alabama Section Meets

MEMBERS and friends of the Alabama Section, ASAE, gathered at Gulf Shores, Ala., on Friday and Saturday, October 1 and 2, for the Section's customary fall outing. Wind and tide frowned on plans for Gulf fishing but fresh water angling and other forms of relaxation proved popular substitutes.

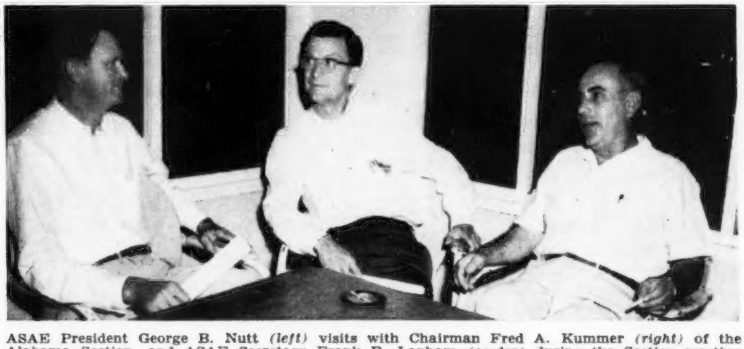
A technical program was presented on Friday afternoon with Lowell Stoddard, Section vice-chairman, presiding. Gene Shelton, Alabama Power Company, told of the experiences of his company in ventilating poultry houses under the high temperature and humidity conditions often experienced in Alabama. Features for the most part found on the agricultural engineering farm at Auburn formed the basis for remarks by J. O. Helms, Jr., dealing with soil and water conservation in mechanized agriculture.

Of particular interest to the group was a paper dealing with the harvesting, processing and distribution of hybrid seed corn. Hybrid corn is making rapid advances in the Southeast, and John Robinson of Robinson Hybrid Seed Company, interestingly described features of this development of particular interest to agricultural engineers. Following a brief intermission, Lloyd Johnson of the agricultural engineering department staff at Auburn stated in a brief presentation that surface irrigation had real possibilities in certain areas of Alabama.

Following the technical program, Chairman A. Kummer introduced ASAE President George B. Nutt who stated that agricultural engineers had a history of which they were rightfully proud. He stated that the profession looked forward to the future with great confidence and a determination to serve the agricultural industry even more effectively than in the past.

ASAE Secretary Frank B. Lanham briefly described some of the functions of the Society's central office.

A highlight of the meeting was the dinner on Friday evening. Lloyd Fuller of Birmingham, known throughout the South for his humor and ability as a master of ceremonies, kept the group in high spirits. E. C. Easter, vice-president of the Alabama Power Company, was scheduled to speak on the Coosa River development program but an emergency prevented his attendance. His remarks were read by M. B. Penn, chief agricultural engineer of the Company.



ASAE President George B. Nutt *(left)* visits with Chairman Fred A. Kummer *(right)* of the Alabama Section, and ASAE Secretary Frank B. Lanham *(center)* during the Section meeting last month

ASAE Meetings Calendar

December 6-8 — WINTER MEETING, Edgewater Beach Hotel, Chicago.

January 28-29 — PACIFIC COAST SECTION, Fresno State College, Fresno, Calif.

February 7-9—SOUTHEAST SECTION, Brown Hotel, Louisville, Ky.

June 12-15, 1955—48TH ANNUAL MEETING, University of Illinois, Urbana

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Cornerstone of New AE Building Laid at Cornell

ON October 6, Governor Thomas E. Dewey of New York laid the cornerstone of the new home of the agricultural engineering department on the campus of Cornell University at Ithaca. Said Governor Dewey on the occasion, "Agricultural engineering, combined with other sciences, has wrought a genuine revolution in the techniques of farming. . . . As we rely increasingly on science and technology, on improved training of our leaders, our teachers, and our people, we will see new vistas of production and happiness which have so far been only a dream." He also said that in the future agricultural engineers "will create new tools and techniques in aid of an even higher living standard for the people in the state and the nation."

Principals who participated in laying the cornerstone of Cornell University's new agricultural engineering building on October 6. *(Left) to right)* President Wm. S. Carlson of the State University of New York, New York's Governor Thomas E. Dewey with trowel, Dean of Agriculture Wm. I. Myers, Cornell President D. W. Malott, and Orval C. French, head of Cornell's agricultural engineering department

Other speakers for the occasion included Deane W. Malott, president of Cornell University; William S. Carlson, president of the State University of New York, of which the college of agriculture at Cornell is a contract unit, and William I. Myers, dean of the College of Agriculture at Cornell.

Cornell's new agricultural engineering building is to be a 2½ million dollar structure and will be opened in the fall of 1955. The lead box placed in the cornerstone of the building by Orval C. French, head of the agricultural engineering department, contained, among other things, a copy of the September, 1954, issue of AGRICULTURAL ENGINEERING.

Irrigation Association Meeting

THE Sprinkler Irrigation Association, a national organization comprising the majority of manufacturers and distributors of sprinkler irrigation equipment, will hold its yearly convention November 14 to 17 at the Boca Raton Hotel at Boca Raton, Fla.

Copies of the program and other information pertaining to the meeting may be obtained by writing direct to the Secretary of the Association, 1028 Connecticut Ave., N.W., Washington 6, D.C.

NEWS OF ASAE MEMBERS

Elliott A. Adams, for a number of years vice-president in charge of engineering of the Massey-Harris Co., was earlier this year made vice-president in charge of product and field research for Massey-Harris-Ferguson, Inc., with the consolidation of the Massey-Harris and Ferguson organizations.

E. A. ADAMS

In addition to directing the product and field research sections of the company, Mr. Adams will act as adviser to H.G. Klemm on Massey-Harris product engineering.

Mr. Adams joined Massey-Harris in 1926 as a field engineer on combines. From 1929 to 1932 he served in Paris, France, as assistant to the general manager of Cie. Massey-Harris. In 1932 he returned to the company's engineering department in Toronto and in 1936 was appointed chief engineer of the company's plant at Racine. Mr. Adams is a native of Pennsylvania and a graduate of Massachusetts Institute of Technology.

P. H. Southwell is leaving his post as experimental officer, mechanical engineering department, National Institute of Agricultural Engineering in England, to accept an appointment as assistant professor of agricultural engineering at the Ontario Agricultural College, Guelph.

Dov B. Krimgold, who since 1952 has held the position of principal research scientist on the staff of the Laboratory of Climatology maintained by The Johns Hopkins University at Seabrook, N. J., and who previously was employed from 1934-1950 in a research capacity by the Soil Conservation Service, USDA, and who also served as assistant of the chief of the Irrigation Census from 1950-1952, recently left for Rome, Italy, to assume his duties as expert in hydrology on the Technical Assistance Program of the Food and Agriculture Organization of the UN. His assignment is to the state of Israel for a period of 4 months to assist in establishing watershed runoff studies, similar to those which he conducted for the SCS for some 15 years. Upon completion of the assignment, he will return to the position he recently left.

Eugene D. Baker is now a field engineer in the research department of the Caterpillar Tractor Co., at Peoria, and is living at 310 West Jefferson St., Washington, Ill. He was formerly with the New Idea organization at Coldwater, Ohio.

John W. Zahradnik, who has been agricultural engineer, Iranian area, for the Near East Foundation for the last three years, is now assistant research professor on the staff of the agricultural engineering department at the University of Massachusetts.

Calvin K. Mutchler, who has been a member of the engineering staff of the research and testing division of The B. F. Goodrich Co. the past two years, recently resigned to accept appointment as research agricultural engineer on the soil and water management research project being conducted cooperatively between the agricultural engineering department, Mississippi State College, and the Eastern Soil and Water Management Section (ARS), USDA. Mr. Mutchler is an agricultural engineering graduate of Ohio State University and, after obtaining his B.S. and M.S. degrees at that institution, served on the agricultural engineering staff of the University of Connecticut for a time.

R. Dale Moore has accepted a position as design engineer with the Kewanee Machinery and Conveyor Co., Kewanee, Ill. He was formerly experimental engineer with The Oliver Corp.

Harold M. Schudt, who has been serving as general manager of the Gadsden, Ala., works of the Allis-Chalmers Mfg. Co., Tractor Division, for the past seven years, has been appointed an assistant to A. W. Van Hercke, vice-president and director of engineering of the Tractor Division of Allis-Chalmers. In his new assignment Mr. Schudt will be responsible for handling the Tractor Division's program of broadening its line of allied products.

HAROLD M. SCHUDT

Mr. Schudt started work with Allis-Chalmers in 1929 under the Marquette University-Allis-Chalmers engineering cooperative program. He served with the engineering department of the Tractor Division from 1935 to 1946 and was then made a tractor representative for the export department and sent to England on a special assignment for two years.

Roland A. Glaze, an ASAE member since 1941 and a past-chairman of the Society's Farm Structures Division, has again become active in the agricultural engineering field. Mr. Glaze was formerly chief engineer of the Weyerhaeuser Sales Co., but left the employ of that company some years ago to accept a sales position with the Toledo Scale Co. More recently he was in charge of this company's division at Seattle, Wash. Mr. Glaze has recently joined Rilco Laminated Products, Inc., manufacturers of glued laminated wood and solid timber structural members. This company is expanding its sales coverage to include the West Coast area, and Mr. Glaze, who is a national authority on wood technology and engineered wood structural members, will be in charge of Rilco's new western office located in the Tacoma Building, Tacoma, Washington. *(Continued on page 816)*

ROLAND A. GLAZE

NECROLOGY

Claude H. Van Vlack, extension professor of agricultural engineering, Iowa State College, for the past twenty years, passed away September 14. He was favorably known throughout the country as an organizer and director of extension programs. He was born May 30, 1890, at Atlantic, Ia., and completed his preparatory work at the Simpson College Academy in 1909. From 1912 to 1917 he engaged in building contracting, specializing for the most part in farm buildings. In 1918, under the influence of wartime conditions, he turned his attention to farming. While living on the farm in 1917 to 1930, he was active as a farm bureau member and was elected president of the Cass County (Iowa) Farm Bureau.

CLAUDE H. VAN VLACK

As the opportunity afforded, he continued his studies in engineering education, using the winter months for this purpose. He completed the requirements for the bachelor's degree in agricultural engineering at Iowa State College in 1929. In 1930 he was invited to take over the instruction in vocational agriculture in the Audubon (Iowa) High School. Using his summer vacations for graduate work he earned the master of science degree in educational administration in 1936 from Colorado State College.

With his training and experience Mr. Van Vlack was particularly well prepared to do extension work in the fields of farm structures and farm utilities.

He should be credited with the plan of using local clubs, organized with the aid of the county agriculture director. The club members were farmers who had a common interest in the installation of a utility or the construction of a building. The project, after organization and planning, was carried out cooperatively by the club members.

He was particularly well fitted by training and experience to direct a program in the construction and modernization of farm houses and repair of farm buildings. He also specialized in the planning and installation of farm utilities such as water-supply and sewage-disposal systems. During recent years he became an authority on building materials and economical construction.

He was the author of numerous bulletins and circulars on building planning and construction. He became a recognized authority on the painting of buildings.

He was a Mason and a member of the ican Society of Agricultural Engineers and the American Society for Engineering Education.

He was a mason and a member of the Kiwanis Club and the Methodist Collegiate Church of Ames.

He was married June 27, 1918, at Atlantic, Iowa, to Ruth L. Stone. She and two daughters and two sons survive; Mrs. John D. Hamilton, Plainfield, Conn.; Mrs. John R. Hutchinson, Madrid, Iowa; Laurence, Ann Arbor, Mich., and Philip, New York City.

Professor Van Vlack always displayed a helpful attitude to those who came to him for consultation. He became well and favorably known in Iowa where he had a host of friends both among his colleagues and the farmers of the state.

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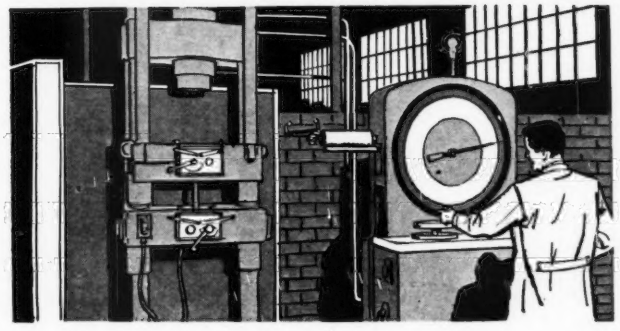

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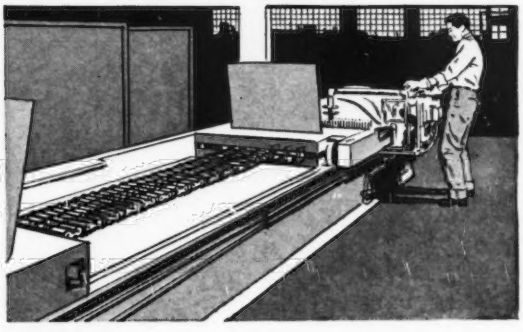

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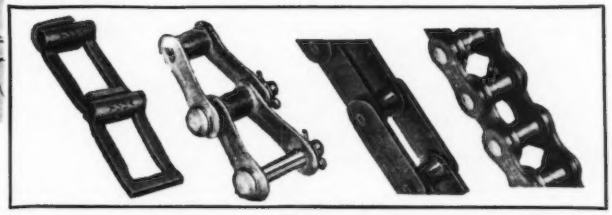

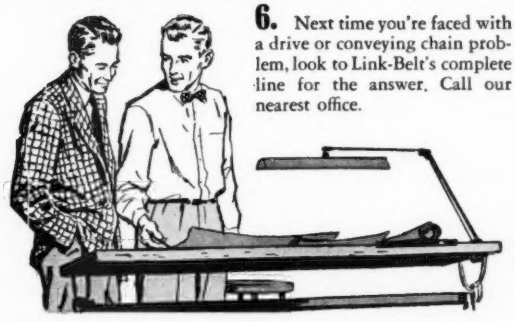

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NEWS OF ASAE MEMBERS

(Continued from page 814)

Carlisle S. Morris has accepted a position as design engineer with the Caterpillar Tractor Co. He was formerly employed as a junior project engineer by the New Idea Farm Equipment Co. His new address is RR 2, Washington, Ill.

Joseph L. Dirnberger has accepted the position of agricultural extension engineer at the New Mexico College of Agriculture, State College. More recently he has been employed as sales engineer for the Portable Aluminum Irrigation Co.

M. J. Shustary, a recent graduate in agricultural engineering and employed for a time in engineering work by International Harvester Co., is pursuing postgraduate study in agricultural engineering at Michigan State College, East Lansing.

Boone Y. Richardson recently accepted appointment as assistant professor on the teaching staff of the agricultural engineering department of Alabama Polytechnic Institute, Auburn. He will be engaged in teaching courses in rural electrification.

Denver O. Baxter recently resigned as extension agricultural engineer at the University of Kentucky to accept a similar position with the Georgia Agricultural Extension Service at Athens.

John W. Layer, who has been serving as district agricultural engineer for the New York State College of Agriculture and stationed at Huntington Station, N. Y., has joined the agricultural engineering department staff of the College at Ithaca.

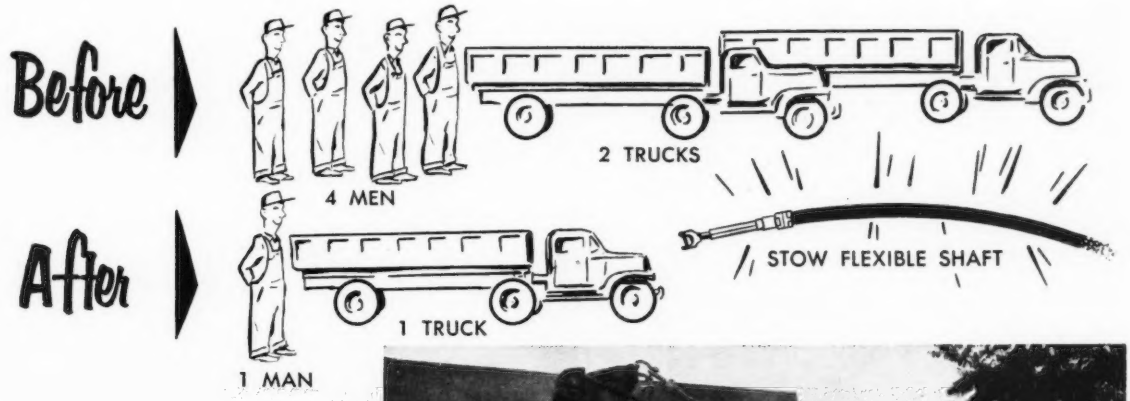
John L. McKitrick is credited in a recent release from Karachi, Pakistan, with a major contribution to agricultural progress in that area. He is completing a two-year period there with the Foreign Operations Administration (Point IV), and is expected to return after a leave in the United States.

His special contribution is a system of workshops to be widely distributed throughout the agricultural area. Each will be a center for the repair of simple farm equipment, the training of local technicians, and research aimed at further adapting equipment and methods to local conditions. Each will have a 300-acre test area. Some are nearing completion and will serve as models for others to be built as the program proves its value. The aim is not to revolutionize the agriculture of the area overnight, but to help the 65 million farmers in Pakistan make a start toward increasing productivity and better living.

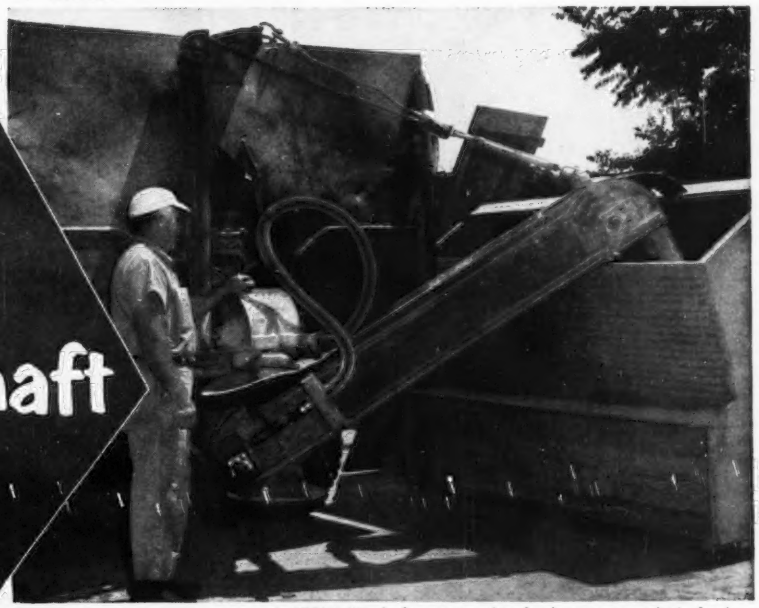
Mr. McKitrick has worked on a variety of technical aid projects in the country, but the shop development program is estimated as likely to have particular far-reaching effects.

Wesley F. Buchele, who recently received a Ph.D. degree in agricultural engineering from Iowa State College, has accepted employment with the Tillage Machinery Laboratory Section in the Agricultural Engineering Research Branch of the U.S. Department of Agriculture. He will be stationed at Ames, Iowa, and will continue in the work of conducting research on the physical properties of seedbeds, in cooperation with the Iowa Agricultural Experiment Station.

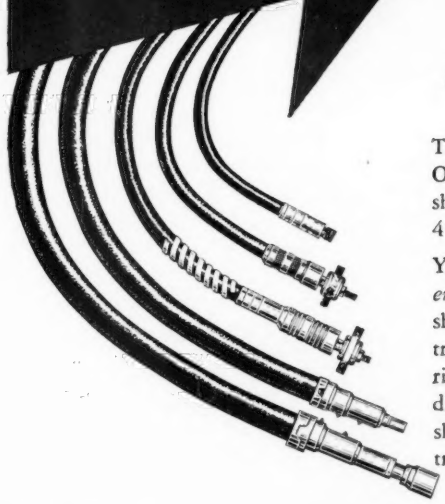
Walter H. Pomerene, formerly employed as an agricultural engineer of the U.S. Soil Conservation Service at its experiment station at Coshocton, Ohio, is now engaged in the business of farming near Coshocton.



A STOW flexible shaft makes the difference



A STOW 1" shaft powers this feed conveyor which feeds 200,000 ducks on a Long Island Duck Farm each day. Formerly 4 men, 2 trucks were required to do the job.



Again ingenuity and a STOW flexible shaft pay off!

Talk about efficiency...
One man, one truck and one STOW flexible shaft now do the job that formerly required 4 men and two trucks—*and in half the time!*

Yes, a STOW flexible shaft *makes the difference.* Perhaps you can use STOW flexible shafting to advantage in some of the power transmission problems you are working on right now. STOW engineers are at your disposal. Check on the advantages of flexible shafting in connection with your next power transmission problem.

Flexible shafting since 1875

Write today for FREE Engineering aids. This handy torque calculator and Bulletin 525 titled Engineering Data are yours for the asking. Write today on your company letterhead.

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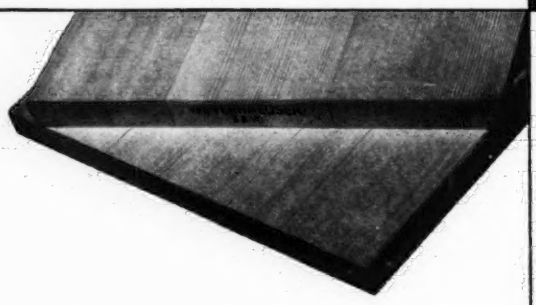
WEYERHAEUSER 4-Square Glued-up bungalow siding of Western Red Cedar is fully as durable as regular siding of the same species.

WIDE glued-up lumber in Western Pines and Associated Species is fully as strong as regular stock.

GLUED-UP lumber takes natural finishes very well, and is ideal for a variety of interior uses such as cabinets.



FINISH of West Coast Hemlock and Douglas Fir is interchangeable with regular stock.

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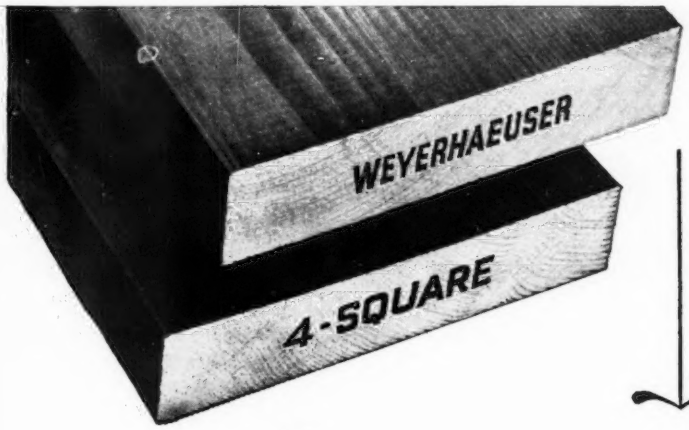
THIS BOOK describes glued-up lumber, lists the items available, and summarizes test results. Copies are available without charge.



this brand name on lumber also brings you

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● Builders are confidently using edge-glued lumber *outside and in*. The supply of desirable wide lumber items has been broadened by Weyerhaeuser 4-Square Glued-up Lumber. With its proved performance record, more and more builders are specifying "glued-up and/or regular stock."

For exterior uses, edge-glued lumber serves as durably as regular stock. Its performance has proved it to be equal to, and interchangeable with, regular stock in species, grades, patterns and uses. It is available in bungalow siding, finish, stepping, selects and wide common items.

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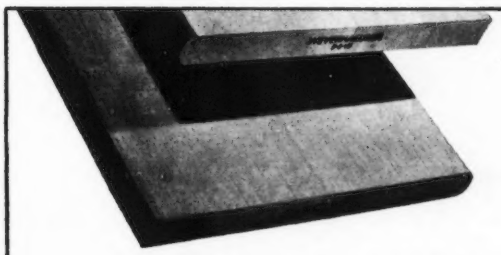
The edge-gluing of lumber for exterior and interior uses is a proved Weyerhaeuser development—one which has been enthusiastically received by the building industry. See it at the yard of your local Weyerhaeuser 4-Square Lumber Dealer, or write for the book on glued-up lumber.



STEPPING of Douglas Fir and West Coast Hemlock is available on an "and/or" basis.

"Why do engineers recommend PRESSURE-CREOSOTED fence posts?"

● Why? Because controlled tests have proved that pressure-creosoted posts last 3 to 5 times longer than most types of untreated posts. That extra-long life reduces repair and replacement costs to a bare minimum, saving the farmer valuable time and money that he can apply to other projects on his farm.

Pressure-creosoting preserves fence posts in another way, too. Repeated grass fires that often damage untreated posts merely char the surface of pressure-creosoted posts, leaving them unharmed.

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NEWS SECTION

(Continued from page 813)

Drainage Conference

THE 10th annual drainage conference sponsored by the Mason City Brick and Tile Co. will be held at the Hanford Hotel, Mason City, Iowa, December 16 and 17.

The program for the conference will feature new and better methods for farm drainage and will be of particular interest to tiling contractors. Agricultural engineers interested in drainage work are welcome to attend.

Concrete Pipe Association Meeting

THE next annual convention of the American Concrete Pipe Association, according to announcement by Howard F. Peckworth, managing director, will be held at the Sheraton-Plaza Hotel, Boston, Mass., on March 9 to 12, 1955.

Information concerning program of the meeting may be obtained later from the Association headquarters at 228 N. LaSalle St., Chicago, Ill.

Agricultural Machinery Society of Japan

THE editor recently received a copy of the June, 1954, issue of the "Journal of the Society of Agricultural Machinery, Japan" which is published monthly. While published in the Japanese language, the titles of technical articles appear in small print under the Japanese title. Also, the more technical articles have a summary or synopsis in English. The copy of the issue received included the following titles of original papers, all by Japanese authors: Results of Fuel Consumption Tests on Small Diesel Engines, Corrosion Resistance of Metallic Materials to Agricultural Chemicals, Lifting Mechanism of the Mower, Research on Sifting Theory of a Grain Sorter, Studies on the Thrower (Elevating Equipment) for Unhulled Rice, Characteristics of Breaking Soil by Motor Tillers, Effects of Wire Tension of the Grain Sorter with Slit System, Cutting Velocity of Rotary Screw Blade of Motor Cutters, and Analytical Investigations on the Declination of Various Properties of Lubricants for Farm Air-Cooled Engines. A table of contents in English is printed on the back cover.

The headquarters of the Society of Agricultural Machinery of Japan is located at the Kanto-Tosan Agricultural Experiment Station, Konosu, Saitama, Japan.

Flushing Bar Protects Pheasants

SINCE pheasants use hay fields to a great extent for nesting, and since mowing operations in many areas usually occur close to the peak of nesting, investigations show a high loss of nests.

A solution to this seasonal problem seems to be in the use of a flushing bar mounted on tractors used for mowing. This bar is a simple attachment mounted on the front of the tractor with weighted cables extending downward from a pole or pipe and dragging through the uncut grass to flush the birds ahead of the mower.

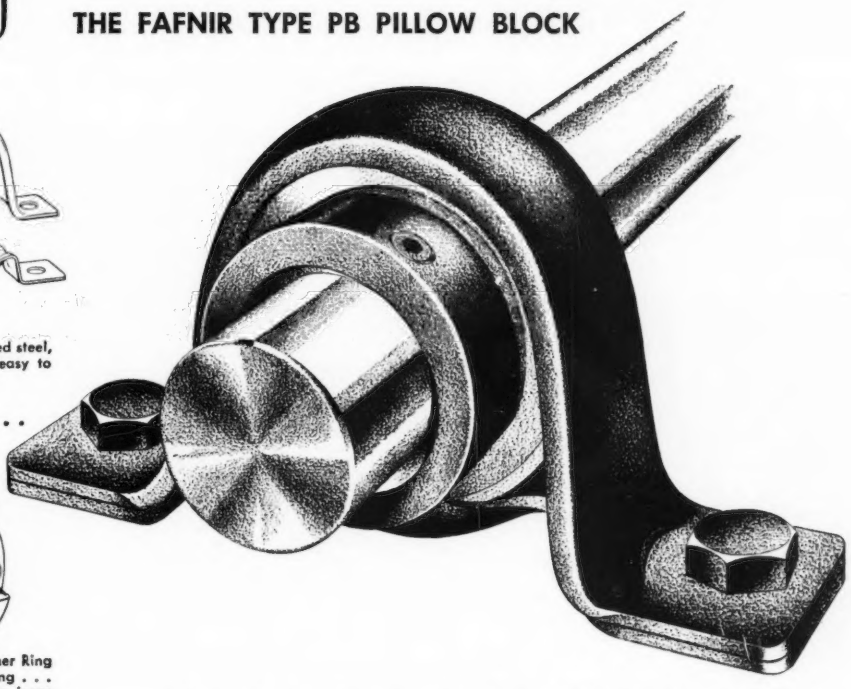
The design of the flushing bar varies with the make and model of tractor and many variations of the idea have been worked out by farmers and others.

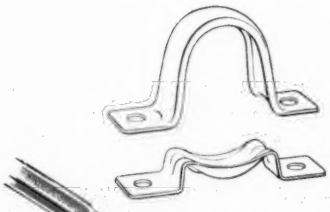
Extension agricultural engineers in the various states might well give special attention to developing designs and specifications and making them available to interested farmers and others interested in game protection.

preference points on power transmission units

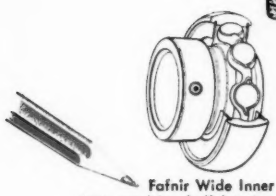
an "economy-package" designed for precision performance

THE FAFNIR TYPE PB PILLOW BLOCK

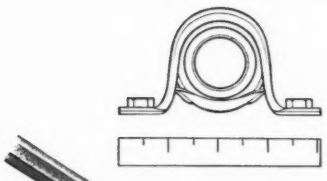




Low-cost, pressed steel, two-piece housing . . . easy to assemble.



Fafnir Wide Inner Ring type precision ball bearing . . . with eccentric cam design inner ring and collar for positive locking action.



Compact . . . unit for one inch shaft size measures only 4¼ inches long, 2¹³⁄₁₆ inches high.

Wherever you need bearings for light duty, slow speed applications, check and compare the Fafnir Pressed Steel Line of Pillow Blocks. With them you get all the advantages of precision ball bearings at surprisingly low cost. They're economical to buy, economical to apply.

Cost-savings are not the only preference points of this Fafnir development, however. *It's a space-saver* . . . takes less than most anti-friction or sleeve bearing mountings. *It saves time* . . . Fafnir Wide Inner Type Ring Bearing with Self-Locking Collar is easiest of all to install. Self-alignment in all directions assures faster, trouble-free assembly. Fafnir patented Plya-Seals minimize maintenance . . . provide positive lubricant retention and protection against contaminants.

Maybe Fafnir Type PB Pillow Blocks can help you save costs and improve your products or equipment as well. Write for literature containing complete specification details. The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

Type PB Pillow Block . . . available in 12 shaft sizes from ½ inch to 1¼ inches . . . radial load capacity from 300 to 600 pounds.

Flangette . . . low cost, two-piece pressed steel housing, choice of two types of sealed bearings, for applications where housing must be attached to a surface at right angles to shaft.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Balsillie, Ian M. — Instructor and fieldman, Kemptville Agricultural School, Kemptville, Ontario, Canada

Becker, A. Ivan—Advanced design engineer, International Harvester Co. (Mail) 3821 10th Avenue Court, Moline, Ill.

Benz, Otto E.—Junior engineer, Bendix Aviation Corp., South Bend, Ind. (Mail) 2227 Myrtle St.

Blagdon, Charles A.—Sales and promotion director, *Farm Implement News*, 608 S. Dearborn, Chicago 5, Ill.

Brittain, Robert W.—Graduate student in agricultural engineering, Michigan State College. (Mail) 254 Maple St., Brevard, North Carolina

Capell, William L.—Technician, engineering assistant, Hydro-Electric Power Commission of Ontario. (Mail) 63 St. Patrick St., St. Catharines, Ontario, Canada

Cerny, Harry R.—Assistant agricultural engineer, California Packing Corp., Box 921, Wahiawa, Oahu, T. H.

Clark, Roy A.—Sales, American Agricultural Chemical Co. (Mail) RR 11, California Rd., Fort Wayne, Ind.

Clark, Stanley J.—2nd Lt., USAF. (Mail) RR 1, McPherson, Kans.

Craig, James T. — Assistant professor in agricultural engineering, Clemson Agricultural College, Clemson, S. C.

Crawshaw, James R.—Technical program, General Electric Co. (Mail) 340 Second St., N.E., New Philadelphia, Ohio

del Valle, Luis F.—Sugar salesman, Compania Azucarera Luis del Valle y Hnos., Havana, Cuba. (Mail) Apartado 2938

Dohrmann, Wendell G.—Production trainee, Ralston-Purina Co. (Mail) 302 N. School St., Normal, Ill.

Elliott, Kendall C.—Assistant in agricultural engineering, West Virginia University, Morgantown, W. Va.

Faber, Henry M.—Production trainee, Ralston-Purina Co., Richmond, Ind. (Mail) 317 S. Eleventh St.

Francis, James M.—Layout draftsman, International Harvester Co., Memphis, Tenn. (Mail) 3539 Charleswood

Hendrickson, Eric T. — Chevrolet Engineering Laboratory. (Mail) 6833 Pinehurst, Dearborn, Mich.

Hessenthaler, Walter H.—Research fellow in agricultural engineering, Rutgers University, New Brunswick, N. J.

Horsefield, William S. — Chief engineer, Whitney Chain Co., Hartford, Conn.

Humpherys, Allan S. — Assistant engineer, Agricultural Research Service SWCB, Utah State Agricultural College, Logan, Utah. (Mail) 361 E. 5th No.

Kazarian, Edward A.—Graduate assistant in agricultural engineering, Michigan State College, East Lansing, Mich.

Knutson, Russell L.—Manager trainee, Simonsen Mfg. Co., Quimby, Iowa. (Mail) Box 92

Lewellen, Oran L. — Agricultural engineer, Texas Power and Light Co., Division Office, PO Box 2033, Tyler, Tex.

Maroko, Moshe—Student in agricultural engineering, Iowa State College, Ames, Ia. (Mail) Friley Hall, Box 826

Miller, Dean E. — Student engineer, John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) 402 Sunnyside

Nissing, Ted J.—Student in agricultural engineering, Louisiana State University, Baton Rouge, La. (Mail) 290 W. Garfield Street

Olinger, D. Richard — Chief product engineer, J. I. Case Co., Anniston, Alabama. (Mail) 3127 Gurnee Ave.

Peterson, Leonard D. — Student in agricultural engineering, Iowa State College. (Mail) RFD 1, Creston, Iowa

Pierce, Lester L.—Sales engineer, Caterpillar Tractor Co., Peoria, Ill. (Mail) 2402 Winifred Drive

Powers, Harold C.—Student in agricultural engineering, Iowa State College. (Mail) RR 3, Creston, Iowa

Robinson, Lynn F. — Lt., USAF. (Mail) AO3019537, Box 272, Ellington AFB, Houston 30, Tex.

Snyder, Carl D.—Farm manager and general contractor, Penn Rich Contracting Co., Inc. (Mail) RD 2, New Tripoli, Pa.

Stewart, Glenn E.—Student in agricultural engineering, Iowa State College. (Mail) RR 1, Hopkins, Mo.

Stout, Bill A. — Graduate research assistant in agricultural engineering, Michigan State College, East Lansing, Mich.

Thompson, Gordon A. — Student, I. S. C. Poultry Farm, Ames, Iowa

Walker, Clyde B. — Salesman, New Way Farm Sales, Inc. (Mail) Thurman, Ohio

Winkle, Roy — Engineer trainee (SCS), USDA, Lancaster, Ohio. (Mail) 233 E. 6th Ave.

Transfer of Membership Grade

Yoerger, Roger R.—Assistant professor of agricultural engineering, Iowa State College, Ames, Iowa. (Associate Member to Member)

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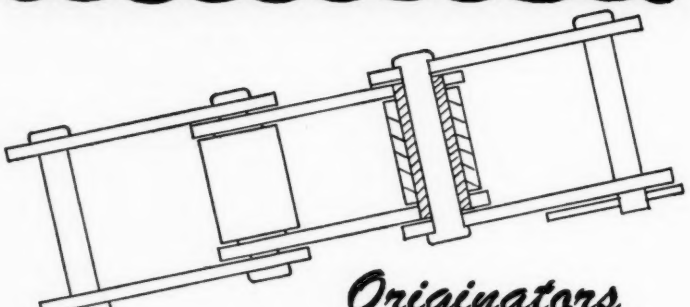

Originators

OF HIGH QUALITY LOW COST IMPLEMENT ROLLER CHAIN

Chains, Incorporated is supplying complete quality chain drives for combines, corn pickers, spreaders and other applications in the agricultural field as well as the industrial field. For the best in roller chain at attractive prices

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A Name to Remember

Experience is a valuable asset in the development, manufacture and distribution of any product. In this respect we offer you the cumulative benefits of *Continuous Service to Industry Since 1887* . . . including origination and pioneering of mass-production equipment for the economical manufacture of washers.

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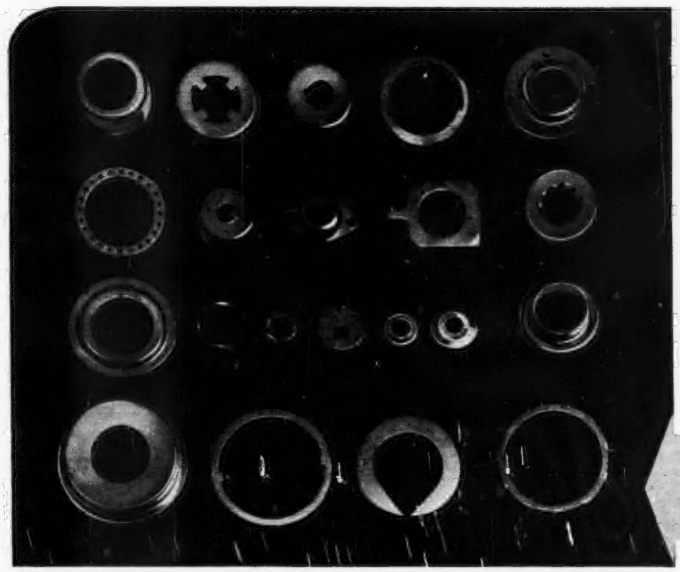

No matter what your washer requirements may be . . . whether for U. S. Standard Washers, SAE Washers, Rivet Washers, Lock Washers, Light Steel Washers, Finishing Washers, Machine Bushing Washers or Special Washers of any size, any desired material or finish . . . "MILWAUKEE WROT WASHERS" is the name to remember! Here, in the world's largest plant devoted to this specialized type of production, we have available more than 25,000 sets of dies — a priceless asset in providing the most complete and comprehensive selectivity to meet your needs.

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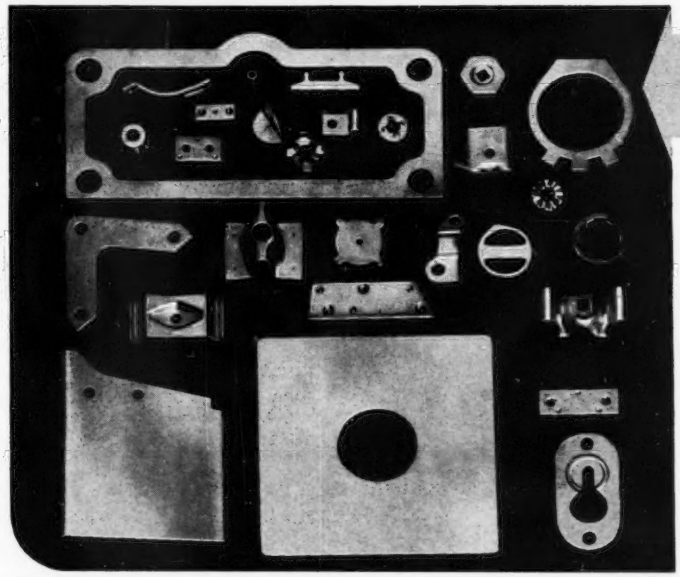
WASHERS



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If it can be punched out of metal—if die-making ingenuity and tool-making facilities can provide the means for producing stampings to meet your production specifications; if the job can be handled most advantageously as a stamping—again, "MILWAUKEE WROT" is the name to remember. Here is a soundly established source of supply you can rely on — plus *Quality Standards* that are a source of pride to us, as manufacturers, and a source of satisfaction to our most discriminating customers. We'd like to serve you.

Let us quote on your requirements . . . covering fabrication in any material and in any finish. Furnished machined, heat-treated or surface-ground, as may be specified.

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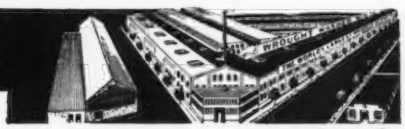

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NEW BOOKS

Farm Buildings, by Deane G. Carter (fourth edition). Cloth, vii+291 pages, 6 x 9 inches. Illustrated and indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N. Y.) $5.50.

This text for college students in agriculture is rewritten and brought up to date to reflect recent progress in materials, design, and outlook on farm buildings. It should help the agricultural student to understand and evaluate farm building functions, to study building needs related to agricultural production, and to deal with engineers, builders, and building supply people in the planning and construction of buildings to meet specific needs. Chapters cover Introduction, Resources for planning, Farm and farmstead planning, Basic planning for farm buildings, Environmental conditions in farm buildings, Building materials; Wood and wood products, Concrete and masonry units, Manufactured building materials, Structure of farm buildings, The parts of structure, Calculating costs and quantities, Farm dairy housing, Beef cattle and sheep housing, Hog housing, Farm poultry housing, Storing and conditioning ear corn, Grain storage and conditioning, Feed-storage structures, Housing farm machinery and equipment, Buildings for limited or special use, The farmhouse, Appraisal of farm buildings, and Farm-building management.

Farm and Dairy Mechanics Laboratory Manual, by V. J. Morford. Paper, ring bound vi + 87 pages, 8¼ x 10¾ inches. Illustrated. Burgess Publishing Co. (426 S. 6th St., Minneapolis 15, Minn.) Price not stated. Fifth revision of a manual originally published in 1948. Instructional procedure and laboratory work assignments and guides in eight units covering hot metal work, cold metal work, farm electrification, soldering and sheet metal, oxy-acetylene welding and cutting, arc welding and cutting, plumbing and pipe fitting, and machinery repair.

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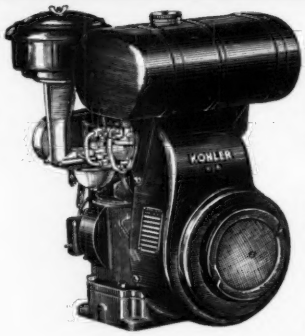
4-CYCLE
AIR-COOLED

K90



K160

K90 3.6 H.P.
K160 6.6 H.P.
K330 11.8 H.P.
K660 26.8 H.P.

Kohler Engines are engineered and manufactured to the high standards which have made the Kohler mark known for quality the world over.

Power for garden tractors, pumps, sprayers, snow removal equipment, grain elevators, hoists, portable saws, concrete mixers, compressors, industrial lift trucks.

Write for information

K330

K660

Kohler Co., Kohler, Wisconsin
Established 1873

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PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS
AIR-COOLED ENGINES • PRECISION CONTROLS

NEW BULLETINS

An Appraisal of Conservation Purpose and Policy, by G. B. Gunlogson. The North Dakota Institute for Regional Studies (Fargo), June, 1954. A 12-page bulletin which discusses not only the goals and instruments involved but also the underlying philosophies and policies relating to the uses and conservation of natural resources. It deals with five main aspects of the subject as follows: The relationship of man and natural resources, conservation in farming needs a rational approach, soil conservation for every farm, conservation in the fields of forestry and wildlife, and an educational approach to conservation and appreciation of natural resources. Copies are available on request to interested agricultural engineers.

Fastening of Gypsum Wallboard with Threaded Nails, by E. George Stern, Bulletin No. 15 (June, 1954) Wood Research Laboratory of Virginia Polytechnic Institute (Blacksburg). Complete comparative test data are presented on the holding power of nails used for fastening gypsum wallboard. These data explain and verify experiences gained in the field indicating that (1) the cement-coated, plain-shank nail provides inadequate holding power for properly fastening gypsum wallboard under many conditions; (2) a threaded nail of special shape offers optimum holding power among the tested nails; (3) use of this threaded nail eliminates most, if not all the problems with which the dry-wall applicator is confronted. Thus, marred gypsum-wallboard surfaces as a result of nailhead popping have been eliminated whenever these newly developed nails were used.

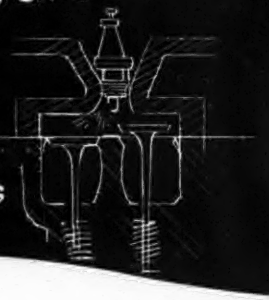
Normal Annual Pattern of Mean Daily Temperatures (at East Lansing, Mich.), by George A. Crabb, Jr. Reprint of Article 36-52 (May, 1954), Quarterly Bulletin, Michigan Agricultural Experiment Station (East Lansing). Text, tabular and graphic presentation of the data with brief discussion of the relation of temperature to insolation and evaporation.

Abstracts on Electric Motors. REA Bulletin 142-6 (April, 1954) Rural Electrification Administration, USDA (Washington 25, D.C.). Abstracts of 29 industrial and public service publications on electric motors for farm use.

The Steam Sterilizing of Soil, by L. G. Morris. National Institute of Agricultural Engineering (Wrest Park, Silsoe, Bedfordshire, England) Report No. 24 (May, 1954). Discussion of temperatures required to kill soil pests and diseases, properties of steam, heating soil with steam, injection of steam into soil and steam production and transmission to the soil.

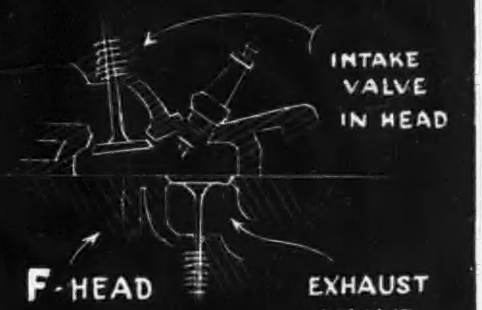
The Infrared Carbon Dioxide Gas Analyzer and Its Use in Glasshouse Research, by L. G. Morris and F. E. Neale. National Institute of Agricultural Engineering (Wrest Park, Silsoe, Bedfordshire, England) Technical Memorandum No. 99 (April, 1954). Notes on the operation, maintenance, and performance of an instrument for continuous recording of carbon dioxide concentration, as used in greenhouse research.

2 EFFICIENT HEAD DESIGNS



L-HEAD →

INTAKE AND EXHAUST VALVES IN BLOCK



INTAKE VALVE IN HEAD

F-HEAD

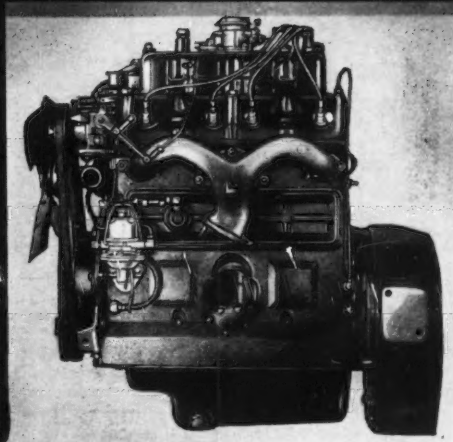
EXHAUST VALVE IN BLOCK

"JOHN" WILLYS *

Engine Chalk Talk

I don't know of another engine manufacturer who can offer the versatility that these two Willys head designs make available. Basically, the "L" head has plenty of power and excellent torque at medium speeds. It is a **rugged** Willys design with plenty of power uses. The "F" head develops even **more** power . . . and smoothly . . . right up to maximum rpm. Its torque curve is almost constant at all speeds. We know this engine will find many applications in equipment where extra lugging power is desirable.

* Design Department, Willys Motors, Inc.



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Willys POWER GIANTS have been designed especially for industrial uses. They are based on the world famed Willys engine designs with "proven-in-action" performance and features.

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Model	Cyl. and Head	Displ. Cu. in.	Range Max. bhp	Range of speed
Jeep	4 L	134.2	22 - 60	1200 - 4000
Hurricane	4 F	134.2	22 - 70	1200 - 4000
Lightning	6 L	161.0	28 - 75	1200 - 4000
Giant Hurricane	6 F	161.0	28 - 90	1200 - 4200

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4 Cylinder Engines

6 Cylinder Engines

Power Units

PROVEN IN ACTION

DISTRIBUTORS: unusual sales opportunities available. Write today.

NEW PRODUCTS CATALOGS

Power Transmission Products Catalog

Morse Chain Co., 7601 Central Ave., Detroit 10, Mich., will send on request to interested readers a copy of its newly revised 8-page, 8½ x 11-inch catalog (B20-53) describing the complete line of Morse mechanical power transmission products. The catalog describes and illustrates silent chain, roller chain and Hy-Vo drives; sprockets, cable chains, drive shafts, couplings and clutches. New information is included in the catalog on taper-lock sprockets, cam clutches and torque-limiting clutches. Brief specifications, stock sizes, applications and descriptions are included for each product.

Crop Drier Report

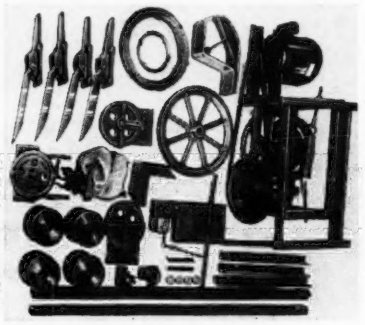
BCR Products, Inc., 488 West Sixth Ave., Columbus 1, Ohio, a subsidiary of Bituminous Coal Research, Inc., has just released an interesting and instructive 30-page report of research and field tests on a new coal-fired crop dryer. The book sells regularly for $2.50, but ASAE members may receive a copy without cost by writing BCR Products, Inc.

New Design Guide

The General Tire & Rubber Co., Industrial Products Division, Wabash, Ind., will send on request to interested readers a copy of its new, 8-page design guide entitled "Motion Control by General Silentbloc"; explains how vibration damping units can be designed and manufactured for specific applications, from refrigeration equipment to giant punch presses.

Packaged Barn Cleaner

Acorn Equipment Co., Stevens Point, Wis., is placing on the market a packaged barn cleaner. The parts necessary for the installation of this cleaner are shown in the accompanying illustration, and include the transmission, various cable-control pulley manure plows, elevator parts and control.



This package, which is complete except for the chute which can be made from local lumber, will take care of the requirements of the average barn and can be installed by the farm owner. It is the invention of one of the pioneers of the pitless type of barn cleaner.

New Rubber, Plastics Catalog

The General Tire & Rubber Co., Industrial Products Division, Wabash, Ind., will send on request to interested readers a copy of its new 16-page brochure describing the complete design - development - production package program which it is offering, and which deals with molded and extruded rubber, extruded plastics, rubber-to-metal bonded parts, vibration and shock control units, and plastics-reinforced fiber glass parts.

Tractor-Mounted Drill

Allis-Chalmers Mfg. Co., Tractor Division, Milwaukee, Wis., announces a new tractor-mounted drill which handles a wide variety of grains and seeds and which has the fertilizer distributor with separate spouts

built in as a standard part. The drill is designed for use exclusively with the company's CA, WD, and WD-45 tractors, is fully mounted, hydraulically lifted and lowered, and quickly attached and detached by means of the snap coupler with which these tractors are equipped.

Seed and fertilizer are deposited in separate bands. The drill is of precision manufacture which makes possible drill accuracy and uniformity of seed spacing at high drilling speeds. Torsion-pressure springs provide individual flexibility of gangs and more even pressure for penetration.

(Continued on page 828)

Proof of *INCREASED PREFERENCE for WISCONSIN Heavy-Duty *Air-Cooled* ENGINES 3 to 36 H.P.

*Based on U. S. Bureau of Census Statistics, Wisconsin Motor Corporation leads the engine industry with 50.72% of total production in the 11 to 176 cu. in. displ. bracket — an industry-wide gain of 1.33%, as summarized below.

Once more U. S. Bureau of Census statistics provide authentic proof of outstanding preference for Wisconsin Heavy-Duty Air-Cooled Engines in the internal combustion engine field.

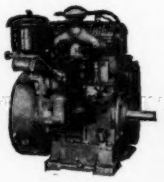
The latest "Facts for Industry" census report, released July 19, 1954, reveals the interesting fact that Wisconsin Motor Corporation produced 5,605 MORE engines in the 11 to 176 cu. in. displ. census grouping than ALL other internal combustion engine manufacturers combined, during 1953. This refers, of course, to engines built for re-sale, exclusive of automotive, aircraft, outboard, miniature and "captive" engines.

Translated into industry-wide percentages, census figures indicate that this company showed a gain of 1.33% over the combined production of all other engine builders. This, however, is an ultra-conservative figure inasmuch as the Wisconsin line covers a range of 13.5 to 154 cu. in. piston displacement whereas the Census Report grouping covers engines from 11 to 176 cu. in. displacement. In spite of this fact, Wisconsin Engine production amounted to 50.72% of the Industry's total in above grouping.

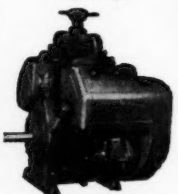
Statistically, these figures are interesting to us as evidence of consistent progress. To the Original Equipment Builder, Distributor and User of engine power, this report provides definite proof of INCREASED PREFERENCE for Wisconsin Heavy-Duty Air-Cooled Engines among people who are best qualified to judge comparative engine values in terms of performance, economy and low-cost maintenance.

You can't go wrong if you specify WISCONSIN Engines for the equipment lines you *sell, build* or use.

4-cycle, single cylinder, 6 to 9 hp.



2-cylinder 7 to 15 hp.



V-type 4-cylinder, 15 to 36 hp.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

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For stress, wear or vibration a

will hold tighter, wear longer, cost less!

The Gripco Lock Nut, with its simple, one-piece design, has given industry a tighter, more positive holding action for quicker fastener application at less initial cost. It provides frictional resistance to vibration and loosening torque—is faster to use—permits repeated removal and reapplication—simplifies production—lowers manufacturing and maintenance costs—has improved the durability of hundreds of products—and has insured greater customer satisfaction. If stress, wear or vibration is your problem, specify Gripco Lock Nuts for greater holding power. Impervious to oil or water. Write for samples and full details.

GRIPCO PRODUCTS INCLUDE: Gripco Lock Nuts, New Gripco "Clinch" Nuts, Gripco Hi-Nuts, Gripco Pilot-Projection and Countersunk Weld Nuts with or without Gripco locking feature.

104

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Who Should Join ASAE

If any one of the following descriptions covers your present work:

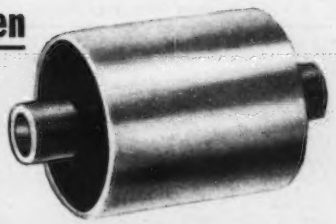
- Development, design, and application of farm tractors and implements and their components
- Design and improvement of farm buildings
- Engineered improvements for soil and water conservation and use
- Creating applications for electricity in farm practice and living—

then you can derive much benefit from membership in ASAE, and the Society cordially invites you to make application. For further information write

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

St. Joseph, Michigan

Farm-Proven Silentbloc Bearings



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These unique rubber-in-metal bearings correct misalignment, reduce noise, cushion shock, and handle oscillating motion *without lubrication of any kind.* In addition, they eliminate metal-to-metal wear and provide long trouble-free operation.

General Silentbloc bearings and bushings are used on agricultural machinery wherever motion is a problem. Special Silentbloc units can also be designed and manufactured to meet your particular need. Our service also covers extruded plastics and rubber, molded rubber and fiberglas, metal stampings, rubber-to-metal. Write for the full story today.

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AE-11-54

New Products and Catalogs

(Continued from page 826)

Agricultural Roller Chain

Link-Belt Co., 220 South Belmont Ave., Indianapolis 6, Ind., will send on request a copy of a dimension data sheet on its AG roller chains, which is an addition to the Company's line of double-pitch chains. The AG chain costs less yet provides the ad-

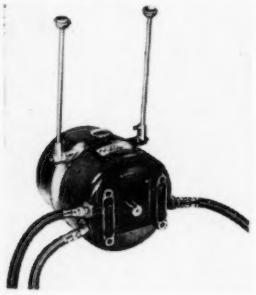
vantages of standard double-pitch roller chain important to farm implement drive and conveyor applications. It intercouples with ASA double-pitch roller chain and operates over the same sprockets (cut tooth or cast tooth). Maximum wear life is assured by uniform heat-treatment of parts and controlled press fits. Link-Belt lock-type bushings increases the chain's ability to withstand shock and heavy loads without stiffening. AG roller chains are now available for testing and production requirements.

Heat-Treatment Fundamentals of Nickel Alloy Cast Irons

The International Nickel Co., 67 Wall St., New York 5, N. Y., will send on request to interested readers , a copy of its bulletin A-115, bearing the above title, consisting of 16 pages, 13 charts and 11 tables on how to increase the usefulness of cast irons and improve the properties by alloying and heat-treatment. Included also is a glossary of terms for easy understanding of the text of the bulletin.

Hydraulic Pump Unit

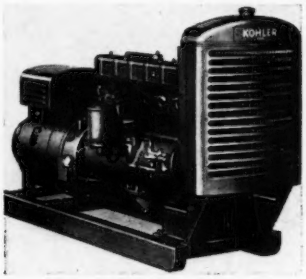
Char-Lynn Co., 2843 26th Ave., So., Minneapolis 6, Minn., advises that its "Hi-Lo-Par" hydraulic pump unit provides a hydraulic pump, oil reservoir, pressure-relief valve, filter and two control valves in one self-contained unit, designed for direct drive from a tractor PTO shaft. Mounting kits are available for all popular tractors.



Specifications for the unit include delivery up to 12 gpm, up to 10 hp; 2½-gal oil reservoir, cartridge-type pressure-relief valve factory set at 1,000 psi, enclosed brass screen filter, drive from 200 to 600 rpm, and two control valves for control of either single-acting or double-acting systems individually or simultaneously.

15-KW Electric Plant

Kohler Co., Kohler, Wis., now has in production a new 15-kw gasoline-powered a-c electric plant. Available in six different models with remote control or stand-by starting, and with varying voltage outputs, the new plant is water cooled with a large radiator, belt-driven centrifugal pump and blower fan. It features an adjustable jet carburetor with automatic choke and a me-

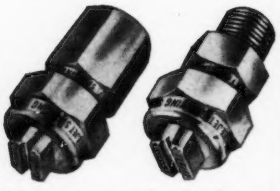


chanical fuel pump with oil-bath air filter. A carburetor and valve kit for converting the fuel supply to natural or artificial gas is available. The six-cylinder engine produces 51 hp at 1800 rpm. Remote starting of the plant is accomplished through an on-off switch on the plant or by two-wire remote control. Stand-by starting, which automatically starts the plant and transfers the load whenever regular service fails, is through an emergency transfer panel with a 75-amp built-in transfer switch.

(Continued on page 830)

for precision

TeeJet®



World famous nozzles for boom and portable sprayers. Choice of over 400 interchangeable orifice tips in flat spray, cone and straight stream types. Write for Bulletin 58.

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Spray up to 66 feet wide with one assembly. For spraying grains, grasses and liquid fertilizers. Write for Bulletins 66 and 71.

for gun spraying

GunJet®

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You will find our experience in WHEEL IMPROVEMENT a treasure store for you in your search for MOBILITY at its BEST. We offer you—

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- DESIGN of SPINDLES and AXLES
- SELECTION of Adequate BEARINGS
- SELECTION of Suitable Closure SEALS
- SELECTION of Sizes, Types, Rubber TIRES

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Our PACKAGE PLAN can save you Research, Development, Tooling Costs. We Invite Your Inquiries.

INTEGRATED ENGINEERING — WHEEL BUILDERS for AGRICULTURE & INDUSTRY — Since 1888

FRENCH & HECHT

DIVISION

KELSEY-HAYES WHEEL COMPANY

DAVENPORT, IOWA

Photo Courtesy THE OLIVER CORPORATION

engineered for dependable performance

MANHATTAN AGRICULTURAL BELTING

Smooth, dependable operation of its belted drives is vital to the efficient on-the-job performance of an automatic baling machine. That's why leading manufacturers of balers and other farm machinery look to Manhattan for agricultural belts to meet their equipment needs. They know that the strength, flexibility and long-life engineered into every Manhattan Agricultural V-Belt, Poly-V Drive or Condor Whipcord Endless Belt enables their machine to perform at top effiiciency in all kinds of weather . . . under the most rigid working conditions.

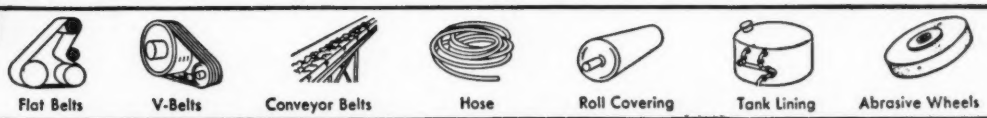
Manhattan belting engineers draw on more than 60 years experience and research in the development of agricultural rubber products to work with the farm equipment manufacturer in designing power transmission drives as nearly fool-proof and trouble-free as possible. Together they produce the most reliable belts available today . . . adding "MORE USE PER DOLLAR" to the equipment they run.

R/M engineers are ready to assist you in determining the Manhattan Agricultural Belt to best meet your requirements... to improve present machine operation or to insure peak performance of your new equipment design. Call on Manhattan to discuss your belting problems.

R/M

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.



Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Bowling Balls. RM-450

AGRICULTURAL ENGINEERS YEARBOOK

Reaches

All members of the American Society of Agricultural Engineers

including

1. Chief engineers, design engineers, and others who specify the designs, components, materials, etc., built into farm tractors and machines.
2. Agricultural engineers in state and federal employ who advise farmers in the selection and application of farm equipment of all kinds.
3. Engineers in soil and water conservation who specify methods, machines, and equipment in irrigation, drainage, and erosion control operations.
4. Agricultural engineers who spearhead advances in functional and structural design of farm-housing and crop-storage buildings.
5. Engineers who have pioneered the engineering applications of electricity on 90 per cent of American farms.

CONTENTS

The 1955 AGRICULTURAL ENGINEERS YEARBOOK will contain items of information which agricultural engineers frequently need to consult, the more important of which are:

- ASAE-approved standards, recommendations, codes, and data.
- Directory of manufacturers (1) of components, materials, etc., specified in designs for farm machines, structures, and other equipment, and (2) of complete machine and structural units used in farming and allied operations.
- Alphabetical and geographical directory of ASAE members.
- Roster of ASAE officers, divisions, sections, and committees, and other organizational information.

AGRICULTURAL ENGINEERS YEARBOOK will be found on the desk of every ASAE member where it serves as a ready reference throughout the year.

Reserve space NOW for the 1955 edition.

Published annually by

American Society of Agricultural Engineers

505 PLEASANT STREET, ST. JOSEPH, MICH.

Also publishers of AGRICULTURAL ENGINEERING

New Products and Catalogs

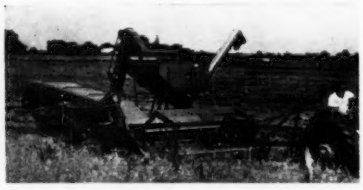
(Continued from page 828)

Brochure on Power Units

Industrial Engine Dept., Willys Motors, Inc., 940 North Cove Blvd., Toledo, Ohio, will send on request to interested readers a 6-page brochure announcing its new power units which are adapted to agricultural and other power needs. The brochure contains complete specifications of engines, standard equipment and housing. It includes information on horsepower, torque and fuel consumption of four 4- and 6-cylinder engines.

New 7-Foot Combine

J. I. Case Co., Racine, Wis., announces its new Model 75 combine that takes a 7-foot swath, which makes it adapted for soybeans, sorghums, and other similar grown crops. The new cutter bar has strong, slender steel guards that makes possible operation in rank, tangled growth without clogging.



"Air-lift" cleaning features a positive-flow fan of variable design which performs efficiently at any selected speeds. The new flat-belt main drive, a feature found on both PTO and engine-driven models, absorbs unexpected shock loads. The machine also includes a dual-position swing-over drawbar for either road travel or field work. Position is changed by moving one pin bolt.

Mounted Disk Plow

Tractor and Implement Div., Ford Motor Co., Birmingham, Mich., announces its new Dearborn PMD disk plow engineered for use with the Fordson Major diesel tractor. This plow, of rugged construction, has three, 26-in heavy-duty disks of heat-treated high carbon steel and is built to withstand severe shock and abrasive action. Attached to the Fordson tractor, it is lifted and lowered by the tractor's hydraulic system. Three adjustments control width and depth of cut

and leveling of the plow. Width of cut can be set from 27 to 33 inches and the maximum depth is 12 inches. Special dust and dirtproof seals protect all bearings. A heavy-duty spring keeps the floating tail wheel in constant contact with the ground, regardless of field contour. Two types of scrapers, the hoe type and the fully adjustable moldboard type are available for use with this plow.

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—APRIL—O-90-613, 106-615. MAY — O-155-623, 108-624, 162-625, 173-626. JUNE — O-181-628, 197-629, 198-630, 182-631. JULY—O-204-633, 205-634, 207-635, 209-636, 208-637, 219-638, 222-639, 223-640, 231-642. AUGUST—O-242-644, 248-645, 250-647, 251-648, 244-649. SEPTEMBER — O-276-650, 262-651, 286-652, 293-654. OCTOBER—O-326-656, 332-657, 327-659, 353-660.

POSITIONS WANTED — APRIL W-125-126, 107-127. MAY—W-146-129. JUNE—W-115-131, 164-133, 169-134, 199-137. JULY—W-177-138, 224-141. AUGUST—W-237-142, 252-143, 265-144. SEPTEMBER — W-246-147, 260-148, 266-149, 294-150, 299-151. OCTOBER—W-296-152, 330-153, 340-154, 365-155, 349-156.

NEW POSITIONS OPEN

SALES ENGINEER to originate and sell manufacturers engineering improvements for farm equipment. Graduate agricultural or mechanical engineer preferred, with at least 6 yr field experience on farm machinery. Must be aggressive, with good sales personality, ability to think quickly, and wide knowledge of farming. Live in Midwest. Excellent opportunity for advancement. Salary open. O-374-661

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for sales and service work in rural electrification or structures in the Middle Atlantic, preferably Virginia. Will travel. Married. Two children. Age 30. No disability. BS deg in agricultural engineering, (1950) Virginia Polytechnic Institute. Farm background. War enlisted service in Army. Area sales engineer for public utility for four years. Available immediately. Salary open with opportunity for commissions. Total earnings including travel expense should be $7000 or better. Will represent highly reputable concern only. W-369-157

AGRICULTURAL ENGINEER for design, development or research in power and machinery with manufacturer in Midwest. Married. Age 41. No disability. BS deg in agriculture 1940, agricultural engineering 1941, Ohio State University. Farm background. Over 6 yr as design engineer with spray equipment manufacturer. Nearly 2 yr as product design engineer, supervisor of field test work, and assistant to chief engineer on line of mowers and rakes. War commissioned service, Corps of Engineers. Available now. Salary open. W-331-158

AGRICULTURAL ENGINEER for extension, field operation, consulting or management work in product processing, field production, soil and water, or farm structures with industry or public service, anywhere in USA. Willing to travel. Single. Age 25. BS deg in 1951, MS in agricultural engineering expected January 1955. Rutgers University. Dairy farm background. Management of dairy farm for short periods. Commissioned service in U.S. Air Force July 1951 to April 1953. Air Installations Officer and Heavy Equipment Officer with supervision over 150 American civilian and Okinawan native personnel in AF construction program on Okinawa. Liaison with civilian contractors with responsibility for distributing government-owned construction equipment, supervision of spare parts warehouse, and supervision of 250-vehicle motor pool. Available February 1955. Salary open. W-372-159

AGRICULTURAL ENGINEER for development, sales, service, or management in power and machinery, soil and water or agricultural chemical field, with industry, preferably on West Coast. Willing to travel. Married. Age 25. Slightly disabled right hand. BS deg in vocational agricultural engineering, 1951, Oregon State College. Work completed for MS deg in agricultural engineering, soils, and agricultural economics, also at Oregon State College. Background on large diversified farm, including 2 yr as assistant manager. Additional summer experience as mechanic and weed control research assistant. Currently plant manager and salesman for aqua ammonia and agricultural chemicals plant. Available on 30 days notice. Salary $500.+, depending on opportunity. W-375-160

Ask for G-E Motors and Control on all Electrified Farm Equipment you buy!

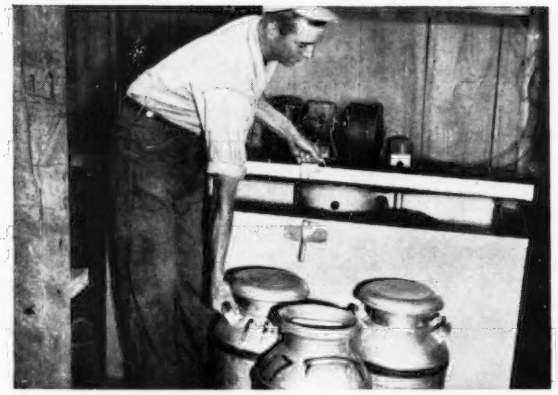
GENERAL ELECTRIC

FarmNews

Ask for G-E Motors and Control on all Electrified Farm Equipment you buy!

MORE POWER TO THE AMERICAN FARMER through more electricity on the farm

Three farmers put low-cost electricity to work to help them raise profits and reduce work load



NEW COOLER ENDS SOUR MILK PROBLEM

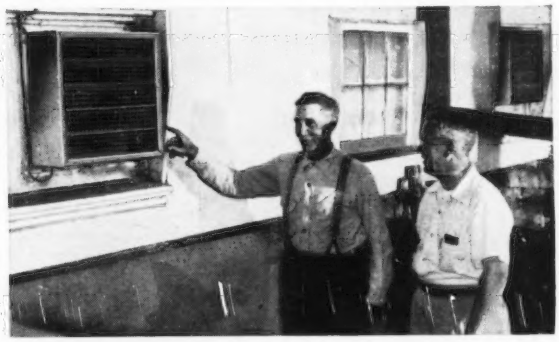
"I don't have any more worries about sour rejects since I got this new milk cooler," says Mr. L. D. Pitcher of Montrose, Ill. This new, low cost cooler, with its big seven-can capacity is economical and efficient to operate. In addition to a rugged G-E motor, it features a completely removable refrigeration unit for easy servicing. An ice reservoir is also provided to keep cans cold in case of emergency. Special timer cools the milk automatically.

ADEQUATE WATER SYSTEM UPS PROFITS

"My new system supplies plenty of water—as a result, hogs gain weight faster and egg production is raised. This means more profit when I sell," says Mr. Gilbert Schroeder of Remson, Iowa. Powered by a reliable G-E motor, Mr. Schroeder's pump provides ample water for all his domestic and farming needs 24 hours a day.

You know how much the cost of running a farm has gone up in the past fifteen years. But while feed bills have almost tripled and labor costs are three to four times as much as in 1939, electricity has gone up *only* 6%! Little wonder that progressive farmers everywhere, like those shown here, are putting low-cost electric power to work more and more.

When you buy electrical equipment for your farm, be certain it has General Electric components—they're your assurance of the best in dependability and performance.



VENTILATING UNIT RAISES MILK YIELD 15%

Nationally known cattle and hog breeder, Mr. A. L. Bidne of Lake Mills, Iowa, says this about his new barn ventilating unit: "Our milk yield increased at least two cans a day since we installed these fans. And now that I can maintain proper air circulation, the barn's a lot healthier place to work." This new fan unit, with dependable G-E motor, control and thermostat, keeps barn fresh and dry; automatically maintains a constant 50°F.

FREE! Mail this coupon!

GENERAL ELECTRIC COMPANY
Section 330-4D, Schenectady 5, N. Y.

I would like additional information on the following:

☐ Ventilator ☐ Water Systems
☐ Milk Cooler ☐ How to Choose Your Motor

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Contents includes (1) ASAE-Approved Standards, Recommendations, and Engineering Data; (2) Directory of Suppliers to Agricultural Engineers; (3) Roster of ASAE Members; (4) List of ASAE Officers, Divisions, Sections, and Committees. Published by the American Society of Agricultural Engineers, this publication is an essential and frequently consulted reference source for every agricultural engineer, as well as for any individual, organization, or library in need of the particular information it contains.
Copies of the current edition of AGRICULTURAL ENGINEERS YEARBOOK are available at $5.00 per copy postpaid. Send order with remittance to
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will it help YOU?

Instant Free Flow

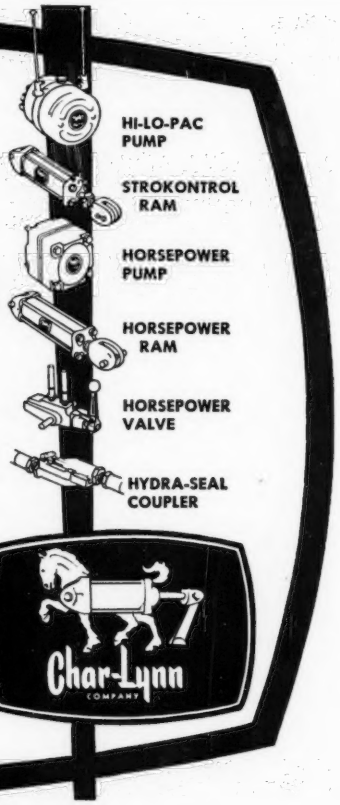
NEW
Char-Lynn
HYDRA-SEAL
HOSE COUPLER

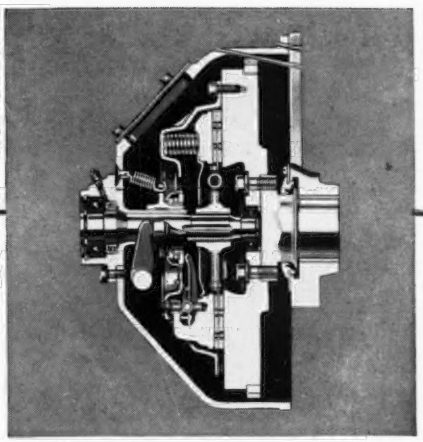
The Char-Lynn Hydra-Seal Hose Coupler has been engineered and designed as a quick-connect self-sealing, break-away coupler for all fluid carrying hoses.

Operation of the Hydra-Seal Coupler is as simple as inserting or removing a plug from an electrical outlet. To couple, hook on and push together; to uncouple, pull apart; no tools are needed. As the barrels are hooked over the slide lugs and the coupler pushed together, the barrels displace the slides and the barrel ports are brought into register or alignment . . . thus allowing the free flow of fluid through the coupler. Pulling the coupler apart brings the slides into position over the ports—oil is sealed in, dirt sealed out.

Let Char-Lynn solve your coupler problems.

CHAR-LYNN COMPANY
AE-11 2843-26th Avenue South, Minneapolis 6, Minnesota
Hydraulic Horsepower To Serve You Better





Cutaway shows New Departure **ball** bearing application in the clutch shaft and pilot positions.

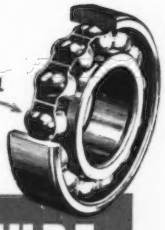
Another **NEW** Tractor Calls for **NEW DEPARTURES**

In the Massey-Harris "44 Special" tractor, you'll find New Departures at work . . . in the generator, clutch shaft, clutch pilot, power take-off and belt pulley drives.

Throughout the farm field, New Departures have proved themselves. They carry thrust, radial or combined loads . . . support moving parts with rigid accuracy . . . allow simple, rugged designs. Above all, New Departure **ball** bearings mean longest life with lowest possible upkeep costs.

So when you design for the farm, *talk with your New Departure engineer.*

NOTHING ROLLS LIKE A BALL



NEW DEPARTURE

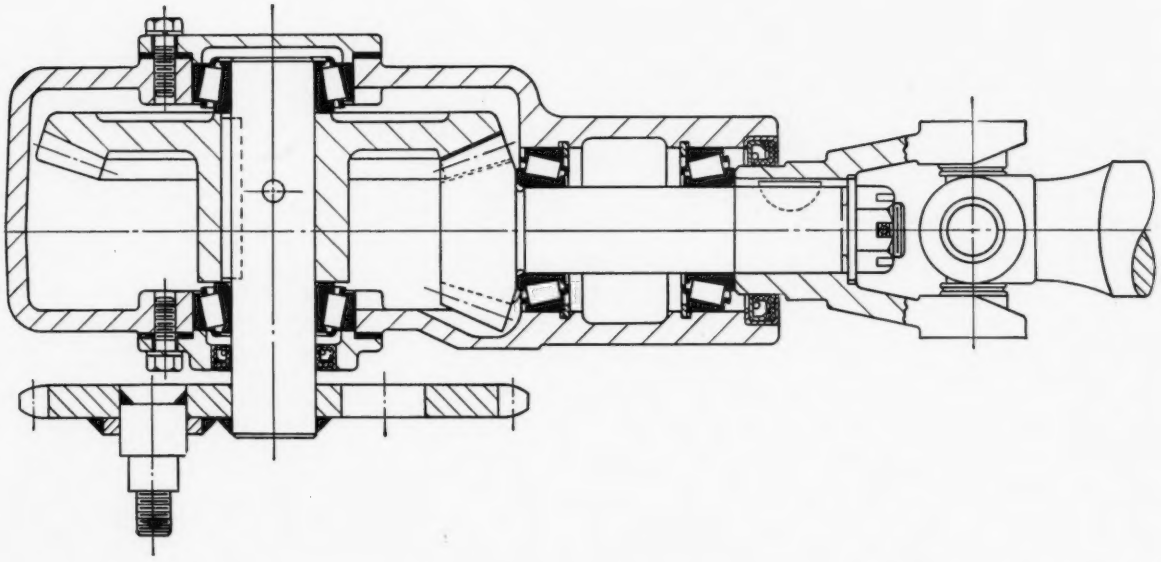
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS BRISTOL, CONNECTICUT

Plants also in Meriden, Connecticut, and Sandusky, Ohio

In Canada: McKinnon Industries, Ltd., St. Catharines, Ontario

How New Holland Engineers Design Extra Savings into a Simple Gear Box



NEW Holland engineers simplified production by using Timken® tapered roller bearings in this gear box for their model 300 large PTO manure spreader. Because the tapered design of Timken bearings enables them to take any combination of radial and thrust loads, they eliminate the need for extra thrust devices.

Timken bearings also minimize gear wear because they hold shafts in rigid alignment, insure accurate gear mesh. And full lines of contact between rollers and races provide Timken bearings with extra load-carrying capacity.

Since Timken bearings keep housings and shafts concentric, they make closures more effective. Lubricant stays in—dirt and water stay out.

Ease of operation is assured, wear held to a minimum because Timken bearings practically eliminate friction. They can because they're designed to roll true and because they're made with microscopic accuracy to live up to their design. And you're doubly assured of Timken bearings' quality because we make our own steel. No other U. S. bearing maker does.

With Timken bearings you can solve these three agricultural engineering problems: combination loads, dirt and ease of operation. For more information on Timken bearings, send for your free copy of "Tapered Roller Bearing Practice in Current Farm Machinery Applications." Write The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The farmer's assurance of better design

Tapered Roller TIMKEN BEARING EQUIPPED

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ↓ AND THRUST →○← LOADS OR ANY COMBINATION